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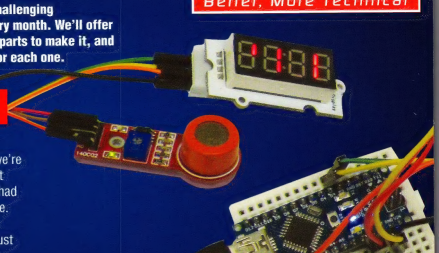

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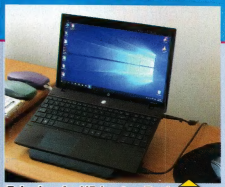

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SILICON CHIP
www.siliconchip.com.au

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SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Offset Alpine, Lidcombe, NSW.

Distribution: Network Distribution Company.

Subscription rates: $105.00 per year in Australia. For overseas rates, see our website or the subscriptions page in this issue.

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ISSN 1030-2662

Recommended & maximum price only.

Publisher's Letter

Small nuclear power stations are ideal for Australia

This month we have a feature article by Dr David Maddison on the topic of small nuclear reactors and when you read it, I am sure that you will agree that small nuclear power stations would be ideal for many locations within Australia. I know that some people may be outraged that anyone would suggest that nuclear power should be used in Australia but it really should be given serious consideration because the other options for base-load power stations are becoming increasingly less attractive to the people who ultimately make the decisions – our politicians.

And while the increasing emphasis on renewables does mean that there is presently a glut of power, at other times when the wind is not blowing, the Sun is not shining and there is a drought stopping hydro generation (eg, in Tasmania), base-load and back-up gas fired stations need to make up the difference.

So we still need base-load power stations and presently it all comes from coal. That presents two big problems. First, most of Australia's coal-fired power stations are very old and cannot keep going indefinitely. They have to be replaced with new coal-fired stations or (choke, splutter) nuclear power stations. Second, coal mining is politically and arguably, environmentally undesirable. This is despite the fact that Australia exports huge quantities of coal to the rest of the world.

A third factor to consider is that Australia's eastern seaboard grid is possibly the largest and most dispersed in the world and that means that large areas are vulnerable to major interruption in supply due to electrical faults, major weather events or even terrorism. It would be much more secure if the power generation was not so centralised in a few locations in Queensland, New South Wales and Victoria.

And as the current failure of the Basslink shows, Tasmania is particularly vulnerable, especially when it is also experiencing a major drought. How much more secure would Tasmania's electricity supply be if there were a couple of nuclear stations there? There could be one near Hobart and one near Launceston.

And before anyone shrieks about the cost, consider the current pickle that Tasmania is in. Basslink is dead and who knows when it will finally be fixed? If it is actually fixed by June, it will have been out of operation for six months. They have very little water left in the dams and perhaps not even enough for human consumption, if the drought does not break soon. And finally, they have had to import dozens of large diesel generators to make up the shortfall. The greenies must find that excruciating – or do they just light another candle?

My guess is that the present Basslink cable will have to replaced in its entirety. In truth, Basslink should not merely be replaced but duplicated, so that if one fails, the other keeps going. Do that twice and the alternative option of a couple of small nuclear power stations could be economically attractive.

Nor does Australia need to go through the ridiculously labyrinthine approval process that is required to build any power station in this country. These small nuclear power reactors can be virtually bought as "turn-key" plants. Order it this week and it could delivered and running within a relatively short time! And consider that some of these plants could also provide desalinated water at a cost *very* competitive with the present "white-elephant" desalination plants in some states.

Australian governments like to boast about their infrastructure projects. Well, our extended grid has many problems. Small nuclear power stations could be the ideal solution.

Leo Simpson

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Soldering SMD parts is difficult

I continue to enjoy constructing many of your projects and while I readily embrace technological change, I wish to comment on the change to surface mount devices. One of the reasons I enjoy electronics as a hobby/profession is the ability to create useful devices that I can troubleshoot and repair if something goes wrong rather than throwing the device in the bin.

I see this all too often in consumer goods. I diagnosed a fault in a not-so-cheap DVD player recently and after sourcing the surface-mount chip via eBay, I attempted to desolder the faulty chip. The chip was glued to the board and even with careful heat application, the fine tracks ended up lifting off the board, with the result of having to write the appliance off.

I see this trend with your projects and I have built quite a few of them with surface-mount devices. I do not find it as enjoyable due to their small size and the components are easily lost. I built your Guitar Effects unit that had a CODEC and SMD PIC and found it frustrating and the whole project wasn't cheap by the time I sourced all the parts. Hopefully it will give me a long service life because if the PIC or the CODEC IC fails, again it will probably end up in the bin (what a waste).

I looked at your charge equaliser for Li-Ion batteries in last month's issue and thought "Nope"! I really appreciate Nicholas Vinen's brilliant designs but have no desire to build a lot of the devices. The same comment goes for the microwave oven leakage detector. I tend to prefer John Clarke's method of using mostly through-hole components with the occasional SMD device in his projects.

I know I'm being a dinosaur and realise that surface-mount is here to stay and this means cheaper and smaller projects but please don't just use them if through-hole parts are available.

Call me old-fashioned but again part of the satisfaction of the hobby is to be able to get your multimeter/logic probe/scope probes onto your project and troubleshoot/improve and repair. I also do remote 4WD trips etc and carry repair gear with me and it is a lot easier to repair through-hole circuit boards when you are in remote locations.

Thanks for a great magazine.

Geoff Coppa,
Emerald, Qld.

Comment: sorry you hate SMDs but unfortunately, many projects would not be feasible if they were based solely or mainly on through-hole components. Many key ICs are only available these days as SMDs or if they available in through-hole form, they are more expensive. We have also based some of our PCBs predominantly on SMDs as they would otherwise be much larger, perhaps impractically so.

SMD soldering tips and tricks

I noticed in your latest magazine some people are having trouble soldering surface-mount components. I have been using these for some years now in small production work, down to 0402 sizes.

My technique is to use a large lump of Blu-Tak (say about 4-6 strips rolled into a ball), stuck to the work bench, flattened with your hand to about a 20-30° angle, so you are looking at right angles to the PCB pressed onto same. Rotation and replacement of a PCB at any angle is so quick and easy.

RIAA valve preamplifier wanted

I loved the Currawong Stereo Valve Amplifier and now I see the lovely stereo preamp (SILICON CHIP, February & March 2016). Now we just need an RIAA preamp to complete the set!

You have previously stated that the performance of a valve RIAA preamplifier would not be up to scratch (Ask SILICON CHIP, March 2016, page 91). While I don't disagree, I'm wondering about the criterion on which you are basing that determination. Vinyl reproduction is fundamentally lower quality than digital audio (assuming a decent compression algorithm, sampling rate etc). So for that reason, surely one would be able to "get away with" a lower performance design.

I'm sure the vinyl-vs-digital argument is just as fraught as that of valve-vs-solid state. I mean, a jewel wobbling in a plastic groove? Of course it will never be able to compete in terms of distortion. However, a hell of a lot of people like the older technology. This has been proved beyond a doubt with the Currawong.

Yes, I like valve stuff. Yes it will never outperform your wonderful Ultra-LD amplifier. Music reproduction is as much about emotion as well as technical perfection and I'm sure a lot of readers would accept the performance of a preamp sporting the ECC83 or the venerable EF86.

John Roberts,
Wellington, NZ.

*Comment: our criteria for rejecting a valve preamplifier has less to do with the level of distortion and more to do with noise. Regardless of how much people may like valve sound, they don't like it accompanied by a lot of hum, buzz or other noise. A first class turntable set-up playing virgin or vinyl records which are not worn or dirty is capable of first class sound. Why make it second rate with a noisy preamp*lifier? *We reckon a projected 50dB signal-to-noise ratio or thereabouts, is second rate.*

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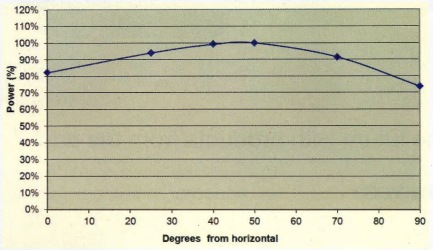
Mailbag: continued



Solar panel tilt is not critical

There has been a lot of discussion about the effectiveness of tilting solar panels in recent months. In theory, you get peak output when the sun hits the solar panel at 90°.

A couple of years ago, I decided to test this on a real 160W solar panel using an MPPT inverter. The peak power from that panel was about 140W on that day. The above graph shows percentage power output against solar panel tilt angle at midday in October in Melbourne, when the sun angle is 45° from the North horizon.

The curve is surprisingly flat. As you can see, the output is above 90% from 15-70°. With the cost of solar panels at $1/watt or below, I doubt if adding tilt frames for solar panels would be worth the added expense.

It is interesting to note that even with a horizontal panel, there is only a 20% drop off in power.

Peter Kay,
Dromana, Vic.

A good pair of tweezers is essential, reworked with a file to suit the job; even better if you can file a very small step in the end so that when you push down on the held component, it doesn't push up into the tweezer points.

Use a 2mm spade iron tip as this will carry a small amount of solder to tin the pad. Use some liquid flux (non-corrosive) then, holding the component in the tweezers, apply to the board and solder one end. Rotate the board 180° and solder the other end. I use 0.5mm or 0.3mm diameter lead-free solder.

Temperature is important (not too hot) and a good magnifying system is essential as you get up in years. I use an eyeglass as I am an ex-watchmaker. Good magnifiers are available, preferably with LED illumination built in.

For multi-pin ICs, just solder one leg and position correctly, then with flux and the iron loaded with solder, just draw the iron down over all the legs on the opposite side and the solder will do all them all in one go. Go back to the first side and repeat to finish.

This applies to solder-masked boards. If soldering to a plain copper (home-made) board, you will probably have to solder the legs individually to control the solder flow. Once mastered, it is much quicker than drilling the board, shaping leads and later cutting of same, and produces a much neater result.

Bernard Smith,
Tallangatta, Vic.

Digital TV Freeview+ incompatibility

I was very interested to read Alan Hughes' article on Digital TV and MPEG-4 in the April 2016 issue of SILICON CHIP. It was an excellent piece on what would seem to be a chaotic situation and may be relevant to the issue I have had for some time with my two year old Sony Bravia KDL-60W850B TV and Freeview.

The TV works fine with Freeview and Freeview+ on all channels with the exception of Ch9. Most functions on their page work OK with the exception of "Catch-UP"; a program can be selected and begins to load and play the obligatory advert but that's as far as it gets.

Although the rotating "loading" icon is working, the program does

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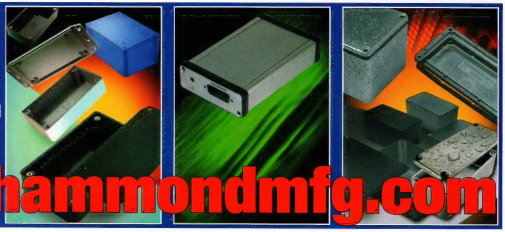
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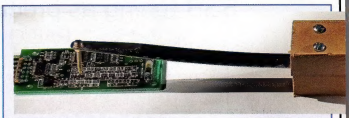

Simple SMD soldering aid

Following the interest in surface-mount assembly I thought I'd send in a photo of the simple jig I have been using for some time. The spring is an old hacksaw blade and the pointer is an 8BA plated brass bolt that has been filed to a blunt point.

Instead of moving the clamp, I simply move the PCB around underneath the fixed clamping point. The PCB illustrated is not under assembly but rather a board out of an old laser printer.

Graham Lill,
Lindisfarne, Tas.

Mailbag: continued

not start. Pressing "Return" and trying again gives the same result.

I contacted Sony and sent them a detailed explanation including some screen shots. They assured me that there was no issue with the TV; it was Ch9. I contacted Ch9 to explained the situation and was told that they were aware that there was an issue with Sony TVs and Freeview and when asked if there was a time frame for a fix, the answer was "no", followed by: "you can watch it on your iPhone or iPad"; clearly not my intention when I bought an expensive 60-inch TV!

I contacted Sony again the same day and they responded: "Channel 9 has recently upgraded its video platforms which causes some issues with Sony units. When broadcasters change or upgrade their formats, we have no way of upgrading pre-installed platforms on the TV, so this causes some viewing problems. Sony makes sure that we release the software or applications needed for these things to work but if a deviation from the original platform occurs then this causes the issue.

It is good that they have advised you that they are aware of the issue and we will coordinate with them as well to find a quicker resolution to this dilemma."

Although this was a good, informative response from Sony, I assumed that the wheels would turn very slowly and eventually the issues would be resolved. However, that same evening I took another look at Ch9 and it had been fixed! I had not received any firmware updates for my TV so obviously it was resolved by Ch9, perhaps with some encouragement from Sony. Anyway thanks to all parties, you have restored my confidence in customer support.

Trevor Moore,
Mount Martha, Vic.

Ultra-HD TV broadcasts are currently pointless

The article on HD TV in your April 2016 issue stirred up my thoughts on the current parlous state of Oz TV.

When you consider the issue of Australian TV standards, with its mix of TV pixel numbers, it is hard to determine at what distance you should sit from your TV. If you set yourself up so that you are just too far to see the full HD pixels then you will find that the majority of channels (still standard definition) do not "look right". They will be blurred or somewhat pixellated.

Yes, the HD channels will generally look good, whilst you will have some misgivings about some channels (those broadcasting 1440 horizontal). If you sit further away and set yourself up for SD TV then you will not be able to take advantage of the higher clarity of the HD channels.

The size of TV set that you should have in your lounge room (or wherever) should be determined by the normal viewing distance from the screen. It is interesting to note that most people choose a TV with a screen size smaller that optimum – probably from the conditioning of available screen sizes for the old analog TV sets.

Now if you are satisfied with your current TV size and viewing distance, then if you are going to watch UHD TV at its full potential you are going to need a TV that is at least twice the size of your current TV screen. If you have a 60-inch screen, you would need to change to a 120-inch one! The average viewer would not consider this to be reasonable. Imagine what an SD TV channel or a DVD playback would look like on a screen that size!

So the first thing that we would need would be for all

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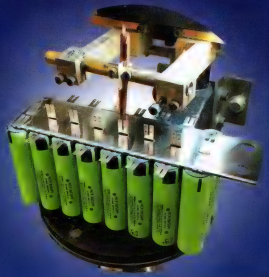

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Mailbag: continued

Enthusiasm for Keysight multimeters

I read Nicholas Vinen's review of the two Keysight meters in the April 2016 issue of SILICON CHIP. Over the past few years, I have used U1233B, U1252A, U1272A and U1242B DMMs (all Agilent's IIRC) and have found them to be quite good instruments. In fact, I own one each of the first three.

When I first acquired the 1233 I thought the LED "flashlight" was a gimmick but after peering in the back of racks a few times, I realised it wasn't. I also thought that I probably wouldn't use the Vsense feature much but it has turned out to be quite useful. I have a 1233 on my bench at work and after my multi-bit ratchet driver, it is probably the item I'd grab most often when I get called on to a job away from my bench.

While Fluke make excellent instruments of great quality and performance (I have owned several and used many over four decades), they are quite expensive by comparison. The U1233C stacks up quite well against the Fluke 179 but costs only half as much and has extra nice features. If you have the money to buy a 179 then the 1272 has superior performance at lower cost.

Of course the Fluke has the advantage that you don't need a degree in computer science to set up all the options or an elephant's memory to recall all the functions, how to access them, what their options are or where to find them – in a word, simplicity.

I would be happy to use a Keysight or Fluke meter in any circumstance it was intended for but if I had to buy a meter with my own money, I'd buy a Keysight.

Phil Denniss,
Darlington, NSW.

channels to be showing only full HD. Until then there is no point in considering UHD TV.

Bruce Withey,
Mylneford, NSW.

Raspberry Pi & Arduino are not competitors

First, an aside: I rather fancy that the "article published in July 1979 ETI", upon which Nicholas Vinen's Microwave Leakage Detector article in the April SC was based, was one of mine from a long time ago. I felt rather flattered reading it. About time for an update I guess.

Regarding the Publisher's Letter in the same issue, I am compelled to comment that the Raspberry Pi and the Arduino should not be seen as competing with each other. I don't see either being ascendant over the other.

The reason for this is deep but significant: Arduino provides no operating system but only a boot-loader, so the programmer is responsible for scheduling tasks, accessing hardware and handling interprocess communication, and is thus open (for example) to bugs arising from non-atomic access to global variables available in interrupts, but can handle making things happen at the moment they are required.

The Pi, on the other hand, comes with a full multitasking operating system but this lies between the application and the hardware. Furthermore, it cannot properly be called a "real-time system" as it can never guarantee that a process will meet a given deadline. These two paradigms are not both suitable for doing very many things, so the majority of times that someone uses one or the other, the alternative would be quite inappropriate.

The choice between these two is both necessary, and with some experience in both arenas, straightforward. I have not used a Micromite or a PICAXE, but I fancy these are in the Arduino camp but a bit more gritty in hardware terms – familiar territory for the hardware-capable reader of SILICON CHIP.

Jonathan Scott,
Hamilton, NZ.

Possible solution for 96kHz DAC problems

I read the letter titled "Stereo DAC Won't Handle 96kHz Signals" in the Ask SILICON CHIP pages of March 2016. I built one of these a few months ago, also bought from Altronics, and I had similar shenanigans with the optical inputs.

Before starting, I had changed the capacitors from 33pF to 100pF as per the errata. Both inputs would randomly pop and burble and each time the input LEDs would flick from green to orange. The coax input was fine.

After opening up the case I began tinkering but couldn't find an obvious cause. I did find that placing a finger on

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Mailbag: continued

Automatic car starter is a bad idea

The Circuit Notebook pages in the April 2016 issue contained a submission by Alexandre Ossine, for an Automatic Starter Circuit for cars.

The submission was made with excellent intent but I feel the author does not fully understand some aspects of vehicle operation and usage and has suggested a circuit that I believe is a high-risk addition to the general configuration of starting circuits in normal cars. (I won't discuss the remote start capability on some of the "supertechnomobiles").

The basic idea of the circuit presented by is to initiate the starting cycle when the ignition is turned on and I believe this has some risky and/or dubious aspects:

- If the keys are left in the car then a child who scrambles into the driver's seat could more easily start the car and cause it to lurch forward or backward and potentially pin a young child or adult under the wheel. This flies against the current general concerns about the number of children being killed or injured by "reversing without looking" and similar accident situations.
- As the author points out, this arrangement relies on the alternator operating correctly and in some circumstances the starter will continue to turn even after the engine has started. This could result in an enormously expensive repair or even a fire. It could also be a risk factor in an accident where we could end up with the engine running, fuel pumping, and damaged fuel lines and the associated high fire risk, etc.
- The author suggests the fitting of a second switch which, when actuated, prevents the alternator-based problems described in the last paragraph. In the real world, I can see this being forgotten almost all the time.
- The author claims that the arrangement will reduce the time the starter motor is running and thus reduce wear and battery drain. This is completely wrong as the time to start is based on a combination of fuel input to the combustion chamber, engine rotation and spark presentation in the combustion chamber and this will be the same whether this circuit initiated the starter motor at ignition-on or as a second action against a spring loaded position of the ignition key.
- I note also that the vehicle owner cannot check accessory function as the ignition-on position will initiate starter motor action, which is likely to be unnecessary and to me has many risks.

My feeling is that this arrangement would not be an approved modification. I will be advising the four Car Clubs I am associated with on the basis that this circuit can't be recommended generally as it introduces considerable risk for no gain in functionality. Also, the risk involved exposes the author to claims and litigation if an accident arises as a result of fitting this to an existing vehicle's electrical configuration and its fitting may cause the insurance company to deny a claim in the event of a fire etc.

I think you should advise readers accordingly.

Ranald Grant,
Brisbane, Qld.

Comment: this Circuit Notebook item was comprehensively panned in the Mailbag pages of the May 2016 issue and was the subject of Notes & Errata on page 104 of the same issue. In addition, we have removed the item completely from the on-line edition.

We are publishing your comments to reinforce the message. It is a bad idea.

top of the optical input in use would kill the signal completely.

After hooking it back up to an amplifier and turning up the gain, I discovered that both inputs were making a hissing noise similar to an FM radio between stations while again, the coax input was totally silent. I tried supplying 5V instead of 3.3V to see if things improved but it made them worse. Putting a finger on the TOSLINK socket clinched it; a local radio station began blaring out!

The fix involved running a wire from ground at the power supply, via a 1kΩ resistor paralleled with a 0.1µF capacitor, to the chassis earth (my usual procedure with audio gear that I build). This improved things considerably but wasn't a complete cure.

On closer inspection, I discovered that the front two pins (closest to the edge of the PCB) of the TOSLINK units are a wire loop, designed to hold the part firmly to the board. Soldering a wire link between these and ground completed the cure.

Unfortunately, during my tinkering I managed to kill one input, so I made a trip to my local Jaycar and picked up their last stock of TOSLINK inputs and made the swap. Interestingly, I didn't need to link the front pins to ground this time.

By the way, the delicate sound this thing produces makes my old, heavily tweaked CD player sound very average! I've had great results following the tweaks I found here:

http://rockgrotto.proboards.com/thread/5237/sc-dac-tweaks

Mike Adams,
Christchurch, NZ.

Digital TV & MPEG4

I have read the article on "Digital TV & MPEG4" in the April 2016 issue and the first thing that came to my mind was: why didn't the consumer alarm bells start ringing after my published letter in SILICON CHIP, February 2012, regarding the Seven network introducing MPEG4 for Ch74 TV4ME in late 2011? Now we have two Full HD channels and three SD channels using MPEG4, with more to come, and suddenly the masses are protesting because their $5000 HD TV purchased in 2010 can't display them.

I even have elderly friends who waited until the last minute in 2013 before analog broadcasts were switched off in Sydney before buying their DTVs from a well known German supermarket. They weren't aware of Ch74 but they are very annoyed now because their investment has only lasted two years.

In our DVB-T infancy, I questioned

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Mailbag: continued

Atmospheric electricity & troublesome clouds

After reading the article on Atmospheric Electricity in the May 2016 issue, I was thinking of my experiences while working with what was then the Department of Civil Aviation. I was based at Adelaide Airport.

About 5pm one Friday night in the early 1980s, as I was about to finish work for the day, I answered the phone; it was from Parafield Airport. Lightning had blown up some modules in the control tower and the non-directional beacon had failed. I replaced the modules in the control tower and then went to the beacon and replaced the RF module.

The large protective zener diode across the PA transistor was shorted. The beacon frequency was about 206kHz and the aerial had inductive loading at the base and capacitive loading at the top. It proved impossible to tune the aerial as a large black cloud remained above. The beacon was finally restored to service on the Saturday.

Another incident occurred at the main VHF communications outlet in the Mount Lofty Ranges overlooking Adelaide. I was called out one night with the report that all VHF communications at the site had failed. On arrival I noticed a big black cloud overhead. The transmitters were all working so all I could do was wait until the cloud had passed over and everything was normal again. Fortunately there were back-up facilities at the airport but with limited coverage due to the Mount Lofty Ranges.

A similar incident occurred at Parafield Airport about midday; all VHF communications had failed. I suspected a similar incident to the above. When I arrived, the sky was clear so I rang the control tower from the ground floor and yes the problem was over.

I have never seen an explanation for this phenomenon and I assume the clouds were ionised and acting like a shield, blocking any radiation.

Brian Thomas,
Fulham Gardens, SA.

the authorities at an Expo at Darling Harbour as to why channels Two, Seven, Nine & Ten were still using VHF instead UHF for metro regions. These channels suffered pixellation problems from something as simple as the washing machine changing cycle or opening the fridge door, whereas SBS on UHF didn't.

The response was along the lines of: "Despite SBS being on UHF Ch28 analog and Ch34 digital, households were successfully able to watch them with their cheap combination VHF/UHF Band 4 antenna. Putting the others onto UHF would mean many households would require a new antenna and we don't want to inconvenience them".

Now back to MPEG4. In the audio world, audiophiles made a huge noise over vinyl and CDs and now we have DAB+ and these same audiophiles are bitterly complaining about severely degraded audio quality due the high orders of compression used. I wrote to you in February 2012 asking about what actually qualifies and quantifies SD, HD and Full HD. I know you can't

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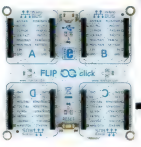

Arduino's two-sided cousin. While it may share many of the same attributes as the popular, open source platform including the 32-bit AT91SAM3X8E core of a Due, the pinout of an Uno and the ability to be programmed in the Arduino IDE via via microUSB, what really sets this new dev board from MikroElektronika apart is when you turn it over.

You'll find four mikroBUS sockets for "click boards." With more than 160 to choose from, Makers can prototype their next gizmo or gadget effortlessly by simply adding new functionality — ranging from Wireless, OLED displays to relays to sensors. That's 160^4 product combinations to set your imagination

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publish every question and letter but seeing the April 2016 issue, nothing has been resolved.

Are you really expecting me to believe that if I was to do an A-B comparison of a movie shown in Full HD on DTV with high compression and low data bit rate to the same movie on Blu-ray, I wouldn't be able to tell the difference? Full HD is 1920 x 1080 pixels and that appears to be it; the content can be compressed as heavily as the broadcasters prefer. All in the name of trying to squeeze more channels into 7MHz!

It's amazing how the Kiwis got it right from the start. All DVT-B is on UHF Band 4 with 8MHz bandwidth or via satellite and all is done with MPEG4. How did our authorities get this costly inconvenience so wrong, again?

Simon Kareh,
Penshurst, NSW.

Comment: you are right about New Zealand. It does seem as though their authorities are much better at making the right technical decisions.

Using excess solar power for water heating

Greg Green makes a good point about the possibility of using excess solar power to heat water (Mailbag, page 12, April 2016). Heated water is a high-capacity energy store and cheaper than batteries (plus the HWS is usually pre-existing). Using a modest dedicated PV array for water heating would probably be too slow but diverting the spare output of a large array would potentially be faster.

A VFD (variable frequency drive) would not vary power to a resistive load, as it does to an AC motor. But hold on, Greg said VSD; that's a DC motor drive and that would do it, so long as it takes an external control signal (either PWM or 10V analog is typical for VSDs).

Cheaper still would be phase control with a Triac, if the 230VAC inverter would tolerate that. Such a box could readily take an opto-isolated PWM input for controlling power diversion. In either case, a PV array monitor could be used to detect how much power is spare. On an off-grid system, battery charging takes priority, so additional smart monitoring is required.

Current planning for my hybrid solar off-grid home & workshop system includes a wood heater-boosted solar hot water heater but the best way to divert excess PV power to its electric boost element is not yet clear.

Would battery voltage measurement (ie, detecting the float stage) plus the detection of minimal charging current suffice for battery full charge detection? A PV array voltage well over Vmp implies spare capacity, I figure. Power could then be drawn from the battery inverter – up to the point where battery discharge would occur. We'd only be drawing power from the array via the 48V DC bus. That would require an MPPT charger and inverter to be dimensioned for the excess capacity.

Much better would be Greg's VSD, driven directly from the PV array, via a separate (parasitic) MPPT device which draws only when the main MPPT isn't pulling the array down to Vmp. That may need a fixed Vmp target to be preset, to avoid two competing MPPTs causing instability. The extra cost of dimensioning the 240VAC inverter

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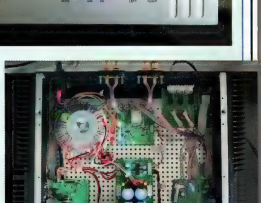
Mailbag: continued

Fancy cases for Ultra-LD Mk.4 amplifier & CLASSiC DAC

I thought you might like to see some pictures of my completed SILICON CHIP DAC (February-May 2013) and Ultra-LD Mk.4 stereo power amplifier (July-September 2015). The preamplifier, input selector and power supply were purchased as kits from Altronics, while I purchased the PCBs for the two amplifier modules and the speaker protector from the SILICON CHIP On-line Shop.



My main challenge, in addition of the completion of the boards, was to find nice enclosures for the two units (I wanted something different from the standard black boxes). Eventually, I found a manufacturer in Bologna, Italy (www.modushop.biz/site) which was able to make customised aluminium enclosures for me, with laser engraving at the back and silk-screening on the front, in addition to the milling and anodisation work for the finishing.

I think the result is excellent. This amplifier enclosure integrates the heatsinks on each side. I designed the front and the back panels using Adobe Illustrator, then sent them the DXF files.

I have been using the amplifier for a while now and I have to say I am very pleased with it. It sounds different from my Pioneer LX85 (AV receiver), with more sound-stage and better voice separation. The sound signature is clearly different and it's a joy to listen to the music.

Olivier Aubertin,
Singapore.

and MPPT charger for excess capacity is sidestepped.

. If the VSD, like most VFDs, first full-wave rectifies its input, then it can run on DC, though only two diodes in the bridge conduct (continuously), potentially limiting its power handling. However, if we're building an MPPT to only use the spare power, it could be made to drive the heater element directly, ditching the VSD.

There are fewer difficulties in oversizing on an off-grid system with a battery inverter. Over-sizing reduces the required battery capacity (big cost saving), by harvesting a larger proportion of requirements on overcast days. That provides a large excess on most afternoons, allowing diversion to water heating.

Erik Christiansen,
Tecoma, Vic.

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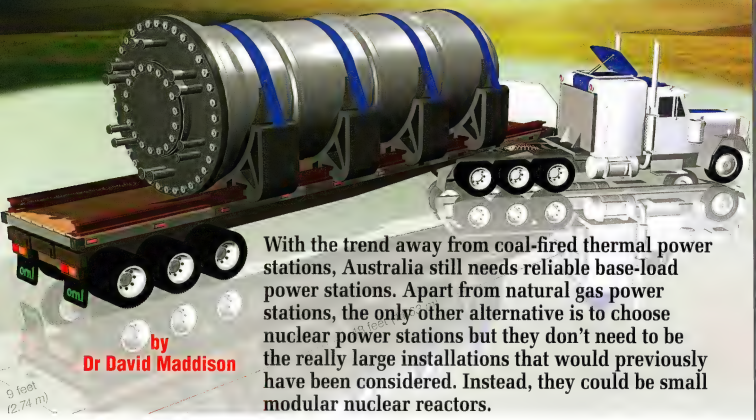


With the trend away from coal-fired thermal power stations, Australia still needs reliable base-load power stations. Apart from natural gas power stations, the only other alternative is to choose nuclear power stations but they don't need to be the really large installations that would previously have been considered. Instead, they could be small modular nuclear reactors.

by
Dr David Maddison

SILICON CHIP discussed new developments in fossil fuel plants with supercritical steam plants in the December 2015 issue (www.siliconchip.com.au/Issue/2015/December/Super+%2526+Ultra-Super-Critical+Steam+Power+Stations)

Now we take a look at new developments in nuclear reactor technology. Around the world, there is a trend away from centralised power generation, partly due to the proliferation of small solar and wind generation plants.

This trend applies to nuclear reactors as well and a number of small size, transportable nuclear reactors are under development.

"Small" nuclear power reactors are regarded as reactors with an electrical output of less than about 300MW, compared with large centralised power stations which might have an electrical output of as much as several gigawatts.

The advantages of a small nuclear reactor, otherwise known as a small modular reactor (SMR), are as follows:

- A small modular reactor can be built in a factory and then transported to the site where it will be used. Mass production should lead to economies of scale, standard designs, centralised quality assurance and lower cost compared to building a reactor on site.
- A small reactor can be located where power is needed and avoids the need for large, high voltage power lines run over long distances.
- Due to the small size of the reactor it can be buried in the ground for an extra level of containment and also the small size allows for passive safety systems that can work with no power whatsoever such as convective cooling.
- If more power is eventually required, such as for a township growing in size, another reactor can be shipped in to supplement the first.
- As the reactor unit is transportable it could be effectively operated as a sealed system and when it needed refuelling, returned to the factory and another unit installed in its place.
- Relatively few staff would be required to operated the reactor.
- Capital costs will be less so there are more financing options.
- The cost of electricity might be a little greater compared to a large reactor but that might be offset by a lower acquisition cost per unit of power, due to the mass production

AR REACTORS

ollution, very low risk

savings of the smaller reactor plus the fact that no long distance power lines are required if the reactor is built near where the power will be used.

- Small reactors are not new, militaries have been using small powerful reactors in nuclear submarines, cruisers, icebreakers and aircraft carriers for many decades with few incidents. Even when the Russian submarine, the Kursk exploded with an explosive force that registered 1.5 on the Richter earthquake scale, the reactors automatically shut down without a problem.
- In the USA an additional reason for interest is that they can be used to replace, on the same sites, a lot of small coal-fired plants which are currently being decommissioned due to age and environmental regulations. In 2010-12 the average size of coal-fired plants replaced was 97MWe (MWe means megawatts of electrical power) and in 2015-25 the size is expected to average 145MWe, so most plants that are to be retired are well within the sub-300MWe size range covered by small modular reactors.
- Due to their transportability they could be used to power remote mining sites or small towns in the outback.
- Some SMR designs claim to response fast enough for "load following", to stabilise the grid to compensate for the highly variable output of wind and solar power and could also be used for peak load and backup units. (Note: the most likely candidates to be suitable for load following are gas-cooled reactors like HTR-PM; see diagram overleaf.)
- Apart from production of electricity, uses of SMRs include desalination, district heating, process heat for industry and production of hydrogen.

The operating principles of small nuclear reactors are much the same as larger ones but can be somewhat simplified due to their smaller size which allows more simple cooling and control systems and the ability to mass produce them which will result in a standard, optimised design.

Operating principles

Nuclear reactors release energy due to a nuclear chain reaction. This process occurs when a single nuclear reaction such as the emission of a neutron from an atomic nucleus causes one or more nuclear reactions in other atoms, starting a self-propagating series of similar events.

When a neutron from the chain reaction hits an atomic nucleus it will be either absorbed or it will cause the nucleus to split. In the event that the nucleus of an atom is split, a process known as fission, a large amount of energy is released.

For fission to occur there must be a source of neutrons plus there must be atoms which are fissionable (capable of being split and sustaining a nuclear chain reaction). Note that fissionable materials are not necessarily fissile, ie, not all fissionable material can be used for nuclear weapons.

In addition, in most reactors the neutrons have to be slowed to a particular speed to be most effective and this is done with a moderator, which is usually normal water (H_2O), graphite or heavy water (D_2O).

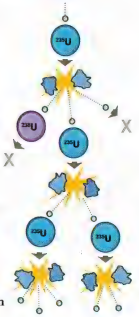
Nuclear fuels

All nuclear reactors require specific fissionable isotopes of certain elements for their operation (see box describing what isotopes are). Three nuclear fuels and their particular isotopes which have been determined to be practical are as follows:

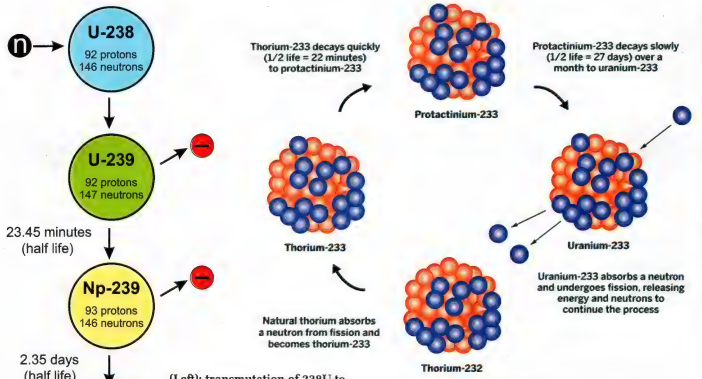
235U (uranium 235) that is enriched from mined uranium, which is mainly 238U. 235U can also be used to build nuclear weapons. Pure 238U is also known as depleted uranium or DU. It is not fissionable but can be converted to a fissionable fuel called 239Pu (plutonium 239) by the process of transmutation inside a reactor (the transformation of one element into another).

235U is the world's most common nuclear fuel and is usually used in a "light water reactor" (LWR).

239Pu (plutonium 239) transmuted from natural mined 238U is used as either a by-product from the normal operation of a power reactor or is deliberately added into the fuel rods. 239Pu is also used in nuclear weapons. This 238U/239Pu fuel is less common and has been used in liquid sodium fast breeder reactors and so-called CANDU reactors (a Canadian pressurised heavy water reactor).



One type of nuclear chain reaction involving 235U. First a neutron hits an atom of 235U which causes it to fission into two new atoms, three neutrons and a large amount of energy. One of the three neutrons is absorbed by an atom of 238U and no further reaction occurs. Another of the neutrons is not absorbed and l eaves the system. The middle neutron shown strikes an atom of 235U causing it to fission (split) just as at the first step, releasing energy and in this case, two more neutrons. The average numberof neutrons released from the thermal fission of uranium is just under 2.5 (slightly fewer when initiated by a fast neutron).



(Left): transmutation of 238U to 239Pu, an important reaction in the nuclear fuel cycle. The small circles represent neutrons or electrons and the arrows indicate whether they are arriving or being ejected. The intermediate isotopes that are created are relatively short-lived and soon decay into the desired isotope.

(Above): transmutation of thorium into uranium which takes around 27 days. When 233U absorbs a neutron, it fissions and releases energy and neutrons. Some of the neutrons it releases are absorbed by 232Th which continues the process of transmuting the thorium.

233U can be transmuted from 232Th (thorium 232). It is best utilised in molten salt reactors (MSRs), specifically Liquid Fluoride Thorium Reactors [LFTRs]).

Note that of these three fuel types, the thorium-based fuel is the only one without military uses in nuclear weapons.

Nuclear fission

After an atom has been split, the total mass of particles involved in the fission process is less than before it because some mass has been converted into energy, according to Einstein's famous equation, $E=mc^2$.

This is millions of times more energy than would be released if the same amount of mass was released in a chemical reaction such as the burning of coal. For example, a piece of 235U the size of a grain of rice contains as much energy as three tonnes of coal. This is the reason why nuclear power is so "energy dense" – a little fuel goes a long way.

In a nuclear power plant the chain reaction is maintained at a constant rate and a runaway chain reaction that would cause a nuclear explosion is impossible due to the purity and physical arrangement of the fissionable material.

In a nuclear explosive device, which contains highly pure fissionable material in close proximity, the design specifically allows a runaway chain reaction which is impossible to stop once started.

In a nuclear power plant the energy that is produced by the fission process is mostly in the form of heat which is typically used to convert water into steam to drive a turbine and alternator to produce electricity.

As noted above, 238U and 232Th are not fissionable materials, ie, their atoms cannot be split. So how can they be used in a nuclear reactor? 238U and 232Th are known as fertile materials.

That means they can be converted (transmuted) into a fissionable material by bombarding them with neutrons.

Small reactors

Electricity was first produced by a nuclear reactor in 1951 and the electrical output was just 45kW. Since then, commercial reactors for electricity production have tended to get larger and larger. There are currently 442 commercial power reactors in operation around the world producing a total of 383,513GW, giving an average output of 868MW per reactor. But now the trend is being reversed.

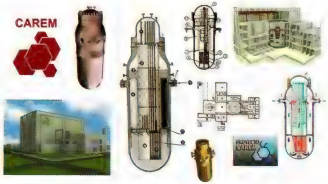
The idea of a portable or modular nuclear reactor is not new. Two notable examples are as follows.

The nuclear reactor near the South Pole

There was once a small "portable" nuclear reactor at the US McMurdo Station in Antarctica. The rationale was to avoid shipping in of vast amounts of diesel for the generators plus steam from the reactor would be used in a desalination plant.

The reactor could produce 1.8MW of electrical power and 56,000 litres of fresh water per day. The reactor went

The PM-3A reactor core being lowered into position at McMurdo Station, Antarctica.



Various views of the CAREM-25 reactor.

critical in March 1962 and after testing and debugging, was operational from 1964 until 1972.

The model of the reactor was designated PM-3A. It was third in a series that were portable and deliverable with a ski-equipped version of the Hercules aircraft, the LC-130. Of the other two reactors in this series the PM-1 reactor was used to power a remote radar station in Wyoming while the PM-2A was used to power a remote US military base in northern Greenland. Each reactor had a power output of 1.25-2.0MW.

Unusually, the 235U fuel was highly enriched at 93.1% which meant that it was weapons grade uranium which is classified as any uranium with greater than 90% 235U. Possibly for this reason, the reactor was under the control of the US Navy's Naval Nuclear Propulsion Unit with a crew of 25. The fuel assembly itself was about the size of an oil drum.

Unfortunately that reactor was not a great success, recording 438 malfunctions over its 8 years of use. It was available only 72% of the time. When it was decommissioned it was found to have leaked radioactive coolant through cracks in the reactor vessel into the soil beneath. That required the removal of 9,000 cubic meters of contaminated soil back to the US mainland along with the reactor itself.

The US Army Nuclear Program started in 1954 and ran until 1977, to develop small portable nuclear reactors to produce electricity and heat at remote locations. Eight different reactor designs were built and the program made a number of significant technical achievements but ultimately it was thought to be a "solution in search of a problem". The reactor mentioned at the McMurdo Station, the PM-3A, as well as the related units PM-1 and PM-2A were part of this program.

A video of the program can be watched at https://youtu.be/HPWDMHH4rY4 (*"Army Nuclear Power Program, 1969"*).

Current small modular reactors

The CNP-300 is China's first commercial reactor design, of which two are in operation in China and commercial operation started in 1994. It produces 310MW of electricity and has a 40-year design life. Two units have also been exported to Pakistan.

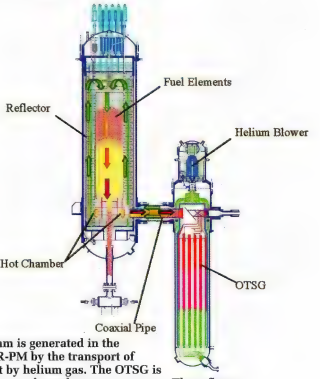
The PHWR-220 is an Indian design producing 220MW and 16 units are in operation. One reason that small reactors were chosen is that it was feared India's electrical grid could not handle the distribution of power from large centralised reactors. Commercial operation of the first one began in 1973.

The EGP-6 reactor is a Russian 11MW design of which four units are in operation at one power plant, built between 1966 and 1976, to serve the gold mine operating in a remote area and are not connected to the national grid.

SMRs under construction

CAREM-25 (Central ARgentina de Elementos Modulares) is a reactor being built in Argentina to produce 25MW of electrical power. The design incorporates passive safety systems and is cooled by natural convection; no coolant pumps are required. Once the design is proven a larger version will be built of 100-200MW capacity.

The HTR-PM reactor (high-temperature pebble bed modular nuclear reactor) is a Chinese design producing 100MW. It will be configured as a twin modular reactor design driving a single steam turbine to produce 200MW of electrical power. The unit uses helium as the coolant and the uranium fuel is in the form of 520,000 spheres. The total installation is known as the HTR-200. It is expected to be connected to the grid in 2017.



Steam is generated in the HTR-PM by the transport of heat by helium gas. The OTSG is the once-through steam generator. The reflector refers to the nuclear core's neutron reflector.

Nuclear fuel cycles

As nuclear fuels are consumed in a conventional uranium-plutonium reactor there comes a time when the depleted nuclear fuel has to be removed and new fuel added. Old fuel needs to be processed and prepared for disposal or it may be recycled in one of two ways.

Spent nuclear fuel from a typical reactor still has most of its original potential energy within it, as only a few percent of the available energy is extracted.

Usually, this nuclear material is considered "waste" and is buried. It has been estimated that if all the nuclear waste generated in the United States in the last 50 years was dug up and reused to extract the residual energy left within it the entire US electrical grid could be run for 93 years at present rates of consumption.

Furthermore, the waste left from this recycling process would only be significantly radioactive for hundreds of years rather than tens of thousands.

The process described above is termed the "once through cycle". Typically uranium ore is mined, enriched, used in a reactor where 235U is gradually consumed and when that is sufficiently depleted the "waste", which contains a variety of fission by-products is treated and buried in long term storage.

An alternative to burying waste is to transmute it into shorter-lived radioactive materials in a "fast burner reactor" but while these exist, the are not yet widely used.

The waste contains potentially useful components such as some unused 235U and some 239Pu.

The closed fuel cycle

The alternative to seemingly wasteful burial of nuclear waste as described above is to recycle it either within the "closed fuel cycle" or the "breeder fuel cycle".

In the closed fuel cycle, useful 235U and 239Pu is extracted from the waste and reintroduced to the reactor as fresh fuel. 239Pu acts much like 235U in a reactor and is used in much the same way. One downside of this process is cost and another is that it involves the extraction of pure plutonium which could be stolen and used to make a nuclear weapon which is why it is not done in most places.

The main useful component of radioactive waste is 238U which is otherwise generally considered useless in a reactor as it is not fissile but it can be converted to something that is fissile which is 239Pu (plutonium).

The conversion of 238U to fissile 239Pu can be done in a special type of reactor called a fast breeder. In this reaction 238U absorbs a neutron and converted to 239U which decays quickly to 239Np (neptunium) which decays quickly to 239Pu.

In the breeder fuel cycle, breeder reactors are used to create new fissile material. They are designed to convert non fissile isotopes to fissile isotope materials like 239Pu from 238U or 233U from 232Th that can be used in a reactor. In this way the nuclear resources are greatly extended and the maximum amount of energy is extracted from the nuclear material. Downsides as with the closed fuel cycle are cost and proliferation issues.

Thorium reactor designs are intrinsically breeders as they convert 232Th to 233U in their normal operation.

Artist's concept of the Russian floating nuclear cogeneration plant the Akademik Lomonosov, currently under construction. It can deliver onshore heat, electricity and fresh water. It will be returned to base for maintenance operations however it can run for 10-12 years before refuelling and has an expected service life of 40 years. See the video at https://youtu.be/VbSSjRS2CnU ("Russia Plans Floating Nuclear Power Plant")

Floating nuclear power plants – the KL-40TS

A floating nuclear reactor is an effective way to deliver power to third world countries with no maintenance capability, deliver high levels of power capacity to regions on a temporary basis such as after a disaster or for a major construction project or to deliver power to otherwise inaccessible regions. Naturally the area to which power is to be delivered must be close to sea, a harbour or a major river.

One example is the Russian Akademik Lomonosov. The vessel was launched in 2010 and it will begin operation in 2018. It is 144m long, 30m wide, has a displacement of 21,500 tonnes and a crew of 70.

It has two model KLT-40C reactors of 150MW thermal and 38.5MW electric power each and an optional reverse osmosis desalination plant that can deliver 240 megalitres per day of fresh water (compare that with Victoria's desalination plant that can deliver 410 megalitres) and can deliver onshore heat, electricity and desalinated water.

Note that this vessel is expected to cost US$336 million (A$444 million) and Victoria's desalination plant cost A$5.7 billion for only 1.7 times the capacity but nearly 13 times the cost.

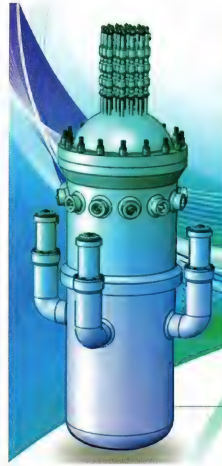
It is built within international regulatory guidelines.

Such a design would be ideal for Africa because they are discouraged from developing fossil power due to international environmental opinion and are expected to develop using solar and wind power which is simply not going to provide their full energy needs at any reasonable cost.

Planned SMRs

The ACP100 is a Chinese design with an electrical output of 100-150MW. Two demonstration units are to be installed in the city of Zhangzhou and will provide electricity, heat and 12 megalitres per day of desalinated water. Construction was scheduled to start in 2015 year and commercial operation in 2017. In addition, China plans to build a floating nuclear power plant based upon this design to be put into commercial production by 2019.

mPower is a design by Babcock and Wilcox for a reactor to produce 180MW. It will be bought to site by rail and combined modules could make a power station of any desired



ACP100 reactor. (*Source IAEA*).

size. The reactor assembly is 4.5m in diameter and 22m tall and will be installed below ground level. Refuelling will be done every four years. A sixty year service life is expected and it has passive safety systems.

The NuScale reactor is smaller than most others with a 50MW output. It is a factory built unit, 3m in diameter and 22m long. It incorporates convective cooling and the only moving parts are the reactor control rods. It is envisaged that a power plant would have 12 modules to give a 600MW power output. Refuelling would be at two year intervals. Design life is sixty years.

This reactor has good load-following capabilities so can be used to back up solar and wind or cope with other rapid variations in grid production. The weight of a module is 700 tonnes and it can be shipped to site by barge, truck or train. Its cost is under US$5,100 per kW. Its reactor can automatically shut down with the complete absence of external power.

South Korea is developing the SMART reactor or System-Integrated Modular Advanced ReacTor. Each unit will produce 90MWe and heat from the reactor will be used to boil salt water in a process to provide 40 megalitres per day of desalinated water. The unit is of the pressurised water design.

Design life of the unit is 60 years and it uses 4.8% enriched fuel that needs to be replaced every three years. There is an agreement in place to build a unit in Saudi Arabia at a cost of US$1 billion.

Future reactor concepts

The General Atomics EM^2 or Energy Multiplier Module is a novel modular reactor designed to consume nuclear waste. As noted in the section on "Nuclear Fuel Cycles" in the conventional fuel cycle only a few percent or less of the potential energy of nuclear fuel has been extracted by the time it is buried as waste. This reactor extracts that remaining energy from what otherwise would be buried.

This gives a good idea of the size of small reactors, with a man shown at the bottom for comparison. In most cases, the vast majority of the reactor would be underground, with only a small building above ground.

Furthermore, once that waste has been through the reactor and its energy extracted, the storage requirements will only be hundreds of years for the waste rather than many thousands. The reactor is extremely versatile in the waste or fuel it can use. It is capable of consuming enriched uranium, weapons grade uranium, depleted uranium, thorium, used nuclear fuel and its own discharge.

A low enriched uranium "starter" fuel is consumed in one part of the nuclear core to transmute used nuclear fuel (waste), 238U or 232Th to fissionable material and the residual of that is then used in a second generation of the cycle.

The reactor is capable of operating for 30 years without refuelling and will also produce 240MW of electricity. (It should be noted that some have argued that this reactor is not as intrinsically safe as other designs).

Thorium-fuelled reactors

Thorium has many potential advantages over uranium and plutonium fuels. It is very common in nature, does

What are isotopes?

Chemical elements are comprised of a nucleus made of protons and neutrons (except the simplest form of hydrogen has no neutrons) and a shell of electrons, the number of which matches the number of protons.

Isotopes are a variation of a particular element in which the nucleus has a different number of neutrons. The number of protons, which defines the atomic number of an element is always the same for any given element, no matter the number of neutrons it has. For a given element, certain isotopes may be stable and others may be radioactive and/or fissile.

Specific isotopes of elements such as uranium and plutonium need to be selected for nuclear power applications while for thorium, no selection is necessary because nearly all the material that occurs in nature is of the one useful specific isotope.

This fortuitous fact means that expensive enrichment to a particular isotope type is not needed, it is simply mined, purified, turned into the appropriate chemical form and used.

Hydrogen, the simplest element and its two isotopes, deuterium and tritium. All have the same number of protons (one) and up to two neutrons. The chemical behaviour of different isotopes is similar. Protium is the name for the common isotope of hydrogen.

not require expensive enrichment and nor can it be used to make nuclear weapons. Thorium can be used in most current and foreseeable reactor designs. Today, thorium would typically be mixed with plutonium or enriched uranium.

While it is feasible to use solid thorium in reactors, the real advantage is that it can be used in a liquid form, in particular as a molten fluoride-based salt.

Such reactors are known as a Liquid Fluoride Thorium Reactors or LFTR (pronounced "lifter"). They are of a general class of reactors known as Molten Salt Reactors (MSRs).

The liquid fluoride salt contains lithium and beryllium, mixed with 233U for the core salt and 232Th in the so-called blanket salt. As previously explained, it is the 233U which undergoes fission and this is the heart of the reactor.

However 232Th is the source of the 233U via transmutation. A salt "blanket" containing 232Th is wrapped around the core where it absorbs neutrons to effect the transformation.

In a LFTR reactor, the molten salt fuel would be continuously processed by chemical means to remove undesired nuclear by-products.

Unlike solid fuels, this is relatively simple to do by pumping the molten salt through a treatment plant while the reactor is operating.

The liquid salt mixture is chemically stable and not damaged by neutrons like conventional solid fuels. Being a liquid it is also the medium used to convey heat out of the reactor to a heat exchanger, to eventually make electricity.

A further advantage is that a reactor based on molten salts is unpressurised, thus eliminating the possibility of failure due to over-pressurisation of the reactor core.

Any notion of a meltdown as can happen with solid fuels is also irrelevant as the fuel is already in a molten state. In addition, if the liquid salt medium should overheat, the power produced automatically reduces, due to a reduction of density of the fuel salt and so the reactor is intrinsically self-regulating.

At the bottom of the liquid salt bath there is a "freeze plug" of the salt solution and it is kept frozen by a fan blowing on it.

In the event of a power failure, the fan stops blowing and the plug melts, enabling the liquid salt to drain into a tank which is passively cooled.

Nuclear Energy in Australia

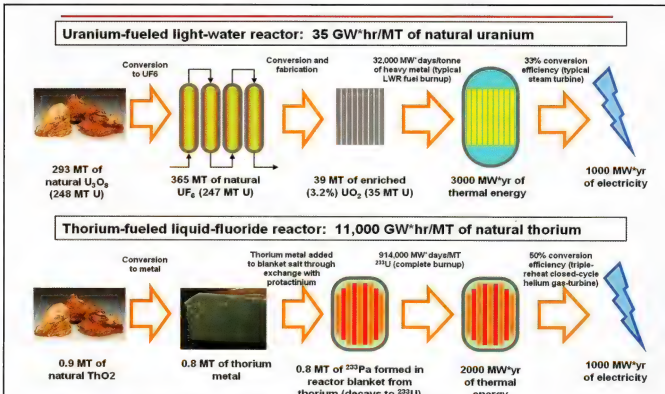
Australia seems ideally placed to use nuclear energy and has abundant supplies of nuclear fuels including the largest reserves of uranium and the third largest reserves of thorium.

In particular, Australia has a large number of remote towns and mining communities which rely on mainly diesel power generation at great cost due to the fact that diesel fuel has to be shipped in.

These places would seem ideally suited to utilise small modular reactors.

In addition, small modular reactors could be used to desalinate otherwise unusable saline bore water or sea water and vast expanses or the outback could be irrigated at relatively low cost.

Australia has seriously considered



Demonstration of the efficiency and energy density of thorium compared to uranium. 248 "MT" (metric tonnes) of uranium is eventually converted to 1000MW years of electricity (i.e. 1000MW continuous production for one year) compared to the same electricity production from thorium with just 0.9 metric tonnes (ie, 900kg). 500 metric tonnes of thorium could supply all of the United States energy requirements for one year.

nuclear power in the past. There was a 1969 proposal for a 500MW reactor to be built in Jervis Bay, NSW which was abandoned in 1971. There was also a proposal to build a reactor on French Island in Victoria.

However, most Australian political parties are openly hostile to nuclear power. Most politicians do not even understand the inherent safety of thorium-based generation.

The overall hostility to nuclear power in this country is unlikely to change anytime soon without a major shift in attitudes – and this is despite the recent (May) announcement of Australia's first repository for nuclear waste.

Small reactors currently in use

Name	Capacity	Type	Developer
CNP-300	300MWe	PWR	CNNC, operational in Pakistan & China
PHWR-220	220MWe	PHWR	NPCIL, India
EGP-6	11MWe	LWGR	at Bilibino, Siberia (co-generation)

Small reactor designs under construction

Name	Capacity	Type	Developer
KLT-40S	35MWe	PWR	OKBM, Russia
CAREM	27MWe	integral PWR	CNEA & INVAP, Argentina
HTR-PM, HTR-200	2x105MWe	HTR	INET, CNEC & Huaneng, China

Small (25MWe up) reactors for near-term deployment – development well advanced

Name	Capacity	Type	Developer
VBER-300	300MWe	PWR	OKBM, Russia
NuScale	50MWe	integral PWR	NuScale Power + Fluor, USA
Westinghouse SMR	225MWe	integral PWR	Westinghouse, USA*
mPower	180MWe	integral PWR	Bechtel + BWXT, USA
SMR-160	160MWe	PWR	Holtec, USA
ACP100	100MWe	integral PWR	NPIC/CNNC, China
SMART	100MWe	integral PWR	KAERI, South Korea
Prism	311MWe	sodium FNR	GE-Hitachi, USA
BREST	300MWe	lead FNR	RDIPE, Russia
SVBR-100	100MWe	lead-Bi FNR	AKME-engineering, Russia

Small (25MWe up) reactor designs at earlier stages (or shelved)

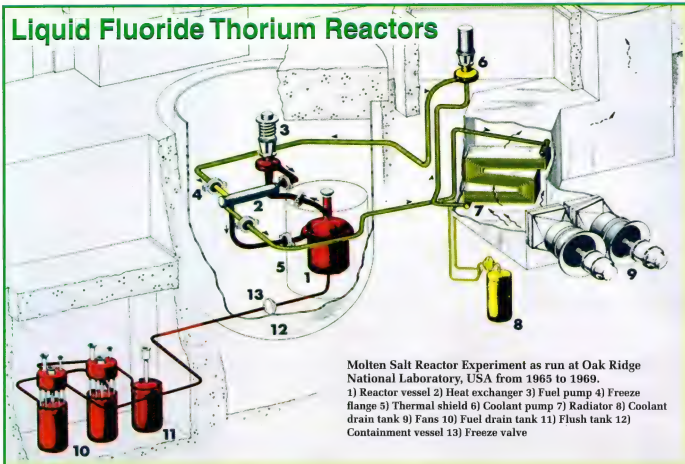
Name	Capacity	Type	Developer
EM2	240MWe	HTR, FNR	General Atomics (USA)
VK-300	300MWe	BWR	RDIPE, Russia
AHWR-300 LEU	300MWe	PHWR	BARC, India
CAP150	150MWe	integral PWR	SNERDI, China
ACPR100	140MWe	integral PWR	CGN, China
IMR	350MWe	integral PWR	Mitsubishi Heavy Ind., Japan
PBMR	165MWe	HTR	PBMR, South Africa*
SC-HTGR (Antares)	250MWe	HTR	Areva, France
Xe-100	48MWe	HTR	X-energy, USA
Gen4 module	25MWe	FNR	Gen4 (Hyperion), USA
Moltex SSR	~ 60MWe	MSR/FNR	Moltex, UK
MCFR	unknown	MSR/FNR	Southern Co, USA
TMSR-SF	100MWt	MSR	SINAP, China
PB-FHR	100MWe	MSR	UC Berkeley, USA
Integral MSR	192MWe	MSR	Terrestrial Energy, Canada
Thorcon MSR	250MWe	MSR	Martingale, USA
Leadir-PS100	36MWe	lead-cooled	Northern Nuclear, Canada

Abbreviation Key:

PWR – pressurised water reactor
LWGR – light water graphite reactor
FNR – fast neutron reactor
MWe – megawatts of electrical power
PHWR – pressurised heavy water reactor
HTR – high temperature reactor
MSR – molten salt reactor
MWt – megawatts of thermal output

This table, from the World Nuclear Association, shows small reactors which are either in use, under construction, are in advanced stages of development or in early stages of development. Some of the latter are currently shelved.

Liquid Fluoride Thorium Reactors



Molten Salt Reactor Experiment as run at Oak Ridge National Laboratory, USA from 1965 to 1969.
1) Reactor vessel 2) Heat exchanger 3) Fuel pump 4) Freeze flange 5) Thermal shield 6) Coolant pump 7) Radiator 8) Coolant drain tank 9) Fans 10) Fuel drain tank 11) Flush tank 12) Containment vessel 13) Freeze valve

More than half a century ago, research into thorium reactors was conducted at the Oak Ridge National Laboratory, USA. From 1955 to 1972 Director Alvin Weinberg and his team envisaged liquid fluoride thorium reactors which would produce both electricity and desalinated water.

But his research was stopped in 1974, as the US made a policy decision to discontinue research into thorium reactors.

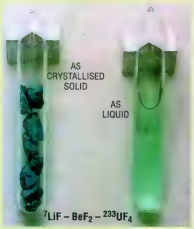
The experiment on the feasibility of liquid fluoride thorium reactors (LFTRs) at Oak Ridge ran from 1965-1969 and was known as the Molten Salt Reactor Experiment (MSRE).

It used a lithium and beryllium salt mixture containing 233U fuel and ran at a temperature of 600-700°C at ambient pressure, producing around 7-8MW of power.

The intrinsic passive safety of this reactor was demonstrated every weekend. When the staff wanted to shut down the reactor on Friday afternoons they simply let the freeze plug melt and the molten salt fuel drained out into tanks. On Monday morning, the salt was reheated and pumped back into reactor.

The LFTR design of reactor has numerous advantages as follows:

- Inherently safe and self-regulating.
- Fuel meltdowns are impossible; the fuel is already in liquid form.
- Unpressurised reactor core.
- It is difficult (if not practically impossible) to use thorium to make nuclear weapons.
- Thorium is abundant and cheap, unlike uranium.
- In the event of an emergency, a LFTR reactor will shut down safely and permanently without any electrical power required or operator intervention.
- If the reactor overheats it produces less power and cools; again, it is self regulating.
- The LFTR has very high fuel "burn", nearly all thorium is consumed and turned into useful energy compared with just 0.5% in light water reactors.
- The high operating temperature of a LFTR reactor, around 700°C results in a high thermodynamic efficiency for steam production to drive a turbine.
- The cost of producing electricity for a LFTR would be 25-50% less than for a light water reactor.

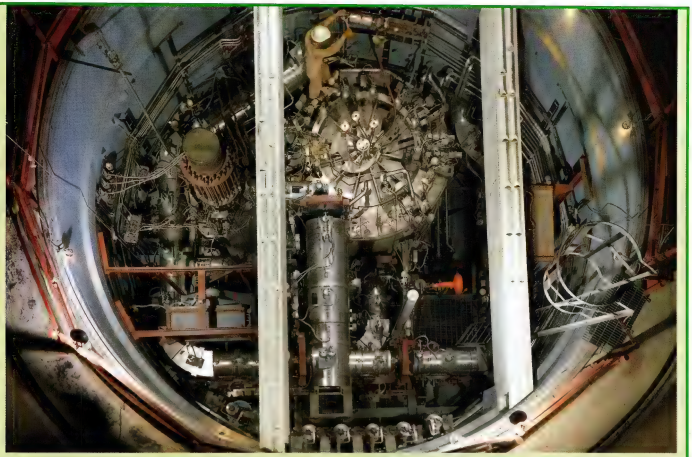


Fuel in the form of a molten salt used to fuel the Molten Salt Reactor Experiment.

Thorium is about as common as lead in nature and much more common than uranium. Thorium is a very energy dense fuel compared to natural uranium.

One tonne of thorium costing US$300,000 could power a 1000MW reactor for one year. One tonne of thorium contains the same energy as 200 tonnes of natural uranium or 3,500,000 tonnes of coal.

The molten salt solidifies at around 150C so if a spill occurs, the salt freezes and it can be scraped up. There is no possibility of radioactive liquid contaminating the ground or of dangerous radioactive aerosols being created.



Looking down into the containment vessel of the Molten Salt Reactor Experiment. The reactor vessel is the large cylinder just off the 12 o'clock position and you can identify some other components by comparison with the schematic.

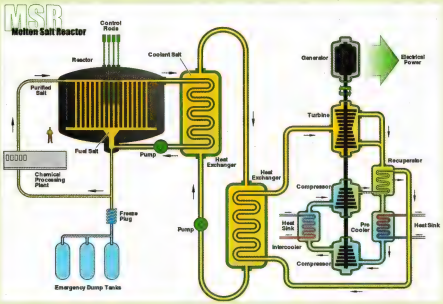
A thorium reactor produces about one hundredth the radioactive waste of conventional reactors and the levels of radioactivity drop to safe levels within a few hundred years (compared to thousands of years compared with conventional unprocessed waste).

While established nuclear energy companies are unlikely to be interested in thorium energy due to their major investments in conventional nuclear infrastructure and resources, there are ample opportunities for entrepreneurial companies to become involved, including Australian companies if the appropriate legislative environment could be created.

The US company Flibe Energy is developing a small modular reactor based on thorium. Their initial offerings will be in the 20-50MW (electric power) range followed by 100MW and more "utility class" units.

They will be mass produced and will first be installed in remote US military bases. The liquid fuel thorium reactor design is highly scalable with power outputs possible from one megawatt up to over a gigawatt.

Some thorium-related Australian web sites are http://thoriumaustralia.org/ and http://thoriumenergy.com.au/



Proposed design for Generation IV Molten Salt Reactor (MSR). Generation IV reactors are a collection of advanced designs that could be demonstrated within the next decade and commercialised from 2030. The nuclear fuel is dissolved in a fluoride salt. Note the freeze plug and the emergency dump tanks. In the event of a power failure, fans that keep the freeze plug frozen will stop, the freeze plug will melt and the entire liquid fuel body will be dumped into the containment tanks under gravity. *Image source: US Department of Energy Nuclear Energy Research Advisory Committee* SC

Bringing an laptop back

By GREG SWAIN

How could I bring myself chuck out a faulty laptop computer with a 1.8GHz AMD quad core processor, 4GB of RAM, a 578GB HDD and 1GB of dedicated video memory? The way out was to try to fix it, even though I'd never torn down a laptop before. What could possibly go wrong?

MEMORY AND hard disk drive (HDD) problems aside, most laptops are simply discarded if they develop a hardware fault. By the time labour and parts costs are factored in, repairs are invariably uneconomic, especially if the machine is more than a few years old.

Sometimes though, it is possible to repair a machine at reasonable cost if you're prepared to have a go at it yourself. It's not for the faint-hearted but there's nothing like a challenge, especially if you've never stripped a laptop down before.

Jan's 4525s

Jan's HP ProBook 4525s laptop was only about three years old when it first began playing up. At unpredictable times, the machine would suddenly crash and display the blue screen of death, with the message that it had encountered a video driver fault. At other times, the entire screen would pixelate and "freeze", so it was showing all the classic symptoms of a video system fault.

Initially, the problem occurred only occasionally and was tolerated. However, as is the nature of this type of fault, it got progressively worse and so her son took the logical next step and reinstalled the video driver. It made no difference and eventually things deteriorated to the point where the machine was all but unusable.

In fact, it sometimes even refused to boot. The HDD would start when the power button was pressed but that was as far as it would go, the screen remaining blank. At other times, it would boot normally but then crash shortly after. And sometimes it would work normally for a week or two before spitting the dummy again.

It was all very frustrating and eventually Jan asked if I would take a look at the machine.

Faulty system RAM?

My initial reaction was that it might be a system RAM fault, since this RAM was probably also shared with the video system. If the RAM was faulty, that would explain why the computer sometimes refused to boot. And on when it did boot, it was crashing when the faulty RAM was accessed by the video driver.

HP ProBook 4525s from the dead

Well, that was the theory but the machine was about to shoot me down in flames.

Jan brought the HP laptop around to my home one Saturday morning and we immediately set it up in the workshop. It turned out to be a well-specced 64-bit Windows 7 machine with a 1.8GHz AMD Phenom II quad core processor, 4GB of system RAM and a 578GB HDD. It also boasted an AMD Radeon HD5000 graphics chip and, as I quickly discovered, 1GB of dedicated video memory.

That meant that the system RAM wasn't shared with the video after all and so my theory that faulty system RAM was the cause of the problem was already looking shaky. After all, why would it indicate a video problem when the machine blue-screened if the system RAM was at fault?

Despite playing up like a second-hand chainsaw the night before, the laptop was now on its best behaviour and I was unable to directly observe the fault. And so, with no better ideas at this stage, I decided to try re-seating the system RAM to see if that would in fact cure the problem – no 2-minute task as it turned out.

Laptops commonly hide their system RAM under a removable flap in the base. Not so on the HP 4525s; instead, it's hidden under the keyboard and you have to partially dismantle the machine to get at it. Fortunately, I'd already googled "access RAM 4525s" and this had revealed a handy YouTube video showing how to do just that.

It's hardly rocket science. The first step is to remove the battery, after which you remove the battery compartment screws and two screws at the rear of the machine (one at either end). The top cover between the keyboard and the LCD is then lifted free. Undoing two more screws then allows the keyboard to be slid backwards (towards the LCD) and lifted clear.

The keyboard is tethered to the motherboard by a flat ribbon cable but it's easy to flip it over and place it to one side on top of the chassis. That done, I removed the single stick of RAM and carefully cleaned its contacts by rubbing them lightly with an eraser and a soft cloth. The RAM was then clipped back into place and the machine reassembled.

It subsequently booted OK and we ran it through its paces. Unfortunately, the "cure" didn't last long; the machine had only been on for about 10 minutes when the display suddenly pixelated and the operating system crashed. Back to square one, as they say.

Jan needed to use the laptop for the time being and so she took it with her when she left. In the meantime, I gave her my Memtest86 CD to run on the machine. This gives the system RAM a real workout and she subsequently reported that despite running the test for several hours, the RAM came up squeaky-clean.

A shiny, new machine

A few more months then went by with the machine continuing to throw ever more frequent tantrums. In the end, Jan decided that she'd had enough and bought a very nice Asus laptop with a Core i5 processor and a full HD (1920 x 1080) display. It came with Windows 8 but we immediately upgraded it to Windows 10. The upgrade went without a hitch and the new Windows 10 install worked beautifully.

Over the next week or so, Jan managed to get the HP 4525s working for long enough to copy all her personal

A hot-air tool was initially used in an attempt to reflow the solder joints under the video chip but the problem was judging just how much heat to pump into it. Although not shown here, aluminium foil was used to shield the surrounding parts and the CPU was removed from its socket prior to applying heat.

This is the faulty motherboard after it had been removed from the chassis and stripped of its CPU, memory and heatsink/fan assembly. Replacing it with a secondhand board bought online was a real gamble.

files onto an external HDD and then delete everything from the machine. It was then turned over to me to see if anything could be done to resurrect it.

By now, my suspicions were that a video hardware fault on the motherboard was the real cause of the problem. Either one of the video RAM chips was faulty or, more likely, the video GPU (graphics processing unit) chip itself was the culprit.

A bit of research on the internet quickly reinforced my suspicions. The video chip is a BGA (ball grid array) device, with the solder joints arranged in a grid underneath the chip itself. And with constant thermal cycling, it's not unheard of for one or more of the solder joints to become intermittent and cause the very symptoms prevalent in this machine.

I also came across some pretty crude "cures" for the problem. One involved wrapping the laptop in a blanket while it was running, so that it got stinking hot – hot enough, presumably, to cure the faulty joint. He's got to be kidding; the chances of that working would be almost zero. In fact, you'd be more likely to damage other parts or start a fire!

Another silly suggestion involved removing the motherboard and cooking it in an oven. Once again, he's got to be kidding.

Among the dross, there were also a couple of reasonably sensible ideas. One involved removing the motherboard and placing some cooking foil over it, with a square cut-out for the video GPU. A heat gun is then used to gently heat the chip, the aim being to heat it just enough to reflow the solder joints underneath (but avoid damaging it), while the foil acts as a heat-shield for the rest of the parts.

Other variations on this involved using a specialised hot-air rework tool or even a professional re-flow station. I didn't have access to the latter but I did have a hot-air rework tool so I decided to give it a go. Of course, judging just how much heat to pump into the graphics chip would be very much hit or miss but what was there to lose?

The first step was figure out how to remove the motherboard. I won't bore you with all the details but in summary, after removing the keyboard, you then remove the front cover with the touchpad, followed by the DVD drive, the HDD and the heatsink/fan assembly. The LCD is then removed by undoing the screws at the hinges and removing its attached cables at the motherboard end, after which you undo lots of hex-head screws and unclip the top plastic chassis frame.

It's then just a matter of undoing a couple of screws and freeing various cables before removing the motherboard from the chassis.

Once the motherboard was out, I took the precaution of removing both the CPU and the RAM module and placing them in an anti-static bag. I then fired up the hot-air tool and gently warmed the graphics chip and surrounding area before really giving the graphics chip the treatment.

It was impossible to know just how much to give it so I simply decided to "heat the hell out of it". After all, it had to get hot enough for the solder joints under it to reflow, otherwise I would be wasting my time. The motherboard was then allowed to cool down, after which I patiently reassembled the computer, plugged it in and optimistically pressed the power button.

Nothing! Absolutely @#$%&! nothing! Not even the power LED would turn on. It was bricked!

There was only one way to fix this computer now and that was to replace the motherboard. Unfortunately, the cheapest (secondhand) board I could get from a supplier on AliExpress at the time was about $120.00. I discussed the matter with Jan and we both decided that it wasn't worth it, especially as there were no ironclad guarantees that the transplant would be successful.

I couldn't throw it out

Now I'm normally a pretty good "chucker" but somehow I just couldn't bring myself to chuck this HP 4525s out. In the back of my mind, I kept thinking that maybe I could pick one up with a broken screen on eBay for next to nothing and transplant the motherboard. Or maybe the motherboards listed on AliExpress would come down in price.

And so the machine sat in one corner of my workbench for several months while I kept my eyes open. Well, good things come to those who wait; the dollar rose, the prices drifted down and I eventually spotted one on AliExpress for $99.00 including delivery.

I didn't want to die wondering, so I ordered it. If the transplant didn't work out, I would simply keep quiet and wear it. On the other hand, if the transplant was successful, I could boast about how clever I was!

The replacement motherboard turned up a week later and I wasted no time stripping the machine down and swapping it into place. This also involved swapping over the CPU and RAM, the heatsink/fan assembly (and associated thermal pads), the audio input socket module and the WiFi module.

While I was at it, I also replaced the on-board lithium back-up battery. The original battery was now about five years old and I didn't want to risk having to strip the machine down again in a few months time to change it.

It was then just a matter of reassembling the machine. This took no more than about 40 minutes and when it was done, I slid the battery into place and hopefully pressed the power button.

Nothing! Absolutely nothing!

But wait – maybe the battery was flat; after all, Jan had mentioned that the battery didn't last long in use and this one hadn't been charged for several months.

I connected the laptop's power supply to the mains, plugged it into the machine and hit the power button again. This time, the power LED lit, the HDD whirred into life and the machine booted straight into Windows 7. And not an error message in sight!

What's more, it seemed perfectly stable and there were no tantrums, even after it had been running for several hours. During this time, I rebooted the machine several times to test it and it started each time without problems. I also entered in my WiFi set-up details, so that the machine had internet access but although everything worked, I wasn't out of the woods yet.

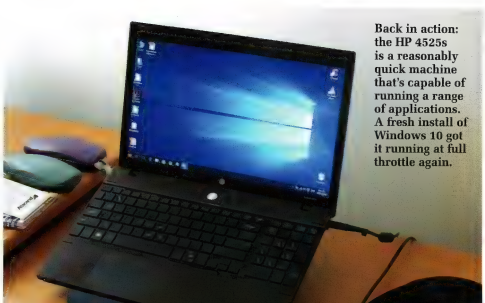
Hairy goat

Where does the expression "it runs like a hairy goat" come from? I dunno but this laptop sure ran like one. It wasn't surprising really, as it had been running like a hairy goat with the old motherboard.

The problem was that a huge amount of software had been installed on it over the years by different family members and the operating system had become mangled. I tried running CCleaner and even ran CCleaner's registry checker but it made little difference. The machine ran reliably but did so very slowly.

A clean install of the operating system was clearly required and the best way to do that would be to first upgrade the operating system (OS) to Windows 10. Once the upgrade was in place and had been activated (this happens automatically if you have an internet connection), I could then reformat the HDD and do a clean Windows 10 install.

As an aside, once a Windows 10 upgrade has been activated, Microsoft has the hardware details for your machine and you can then do a clean install without having to enter a product key. What's more, Windows 10 will then automatically activate again once you've set up an internet connection.



Back in action: the HP 4525s is a reasonably quick machine that's capable of running a range of applications. A fresh install of Windows 10 got it running at full throttle again.

I had previously downloaded Windows 10 64-bit using Microsoft's Media Creation Tool and had burnt it to a DVD. However, when I attempted to run this, it would only get about 23% of the way into upgrade before hanging.

From past experience, I knew that out-of-date programs can stop the upgrade process, so I uninstalled as many applications as I could, cleaned up the registry and tried again. That did the trick – the Windows 10 upgrade now installed without a hitch.

As expected, it still ran like a hairy goat and so, after checking that Windows 10 had activated (right-click "This PC" and click "Properties"), I booted from the Windows 10 DVD, reformatted the HDD and did a clean install. Once again, it all went without a hitch and I was looking at the new desktop after about 30 minutes.

This utterly transformed the machine. Whereas before it had been a slug, it was now fast and responsive, in keeping with its specifications. The machine was back from the dead and it was working flawlessly with one exception.

When I looked at the System Properties dialog, it indicated a missing HP AHCI driver. This driver parks the HDD's heads when the machine is powered down and is vital in a portable device such as this. Retrieving and installing the indicated driver from HP's website soon solved that problem.

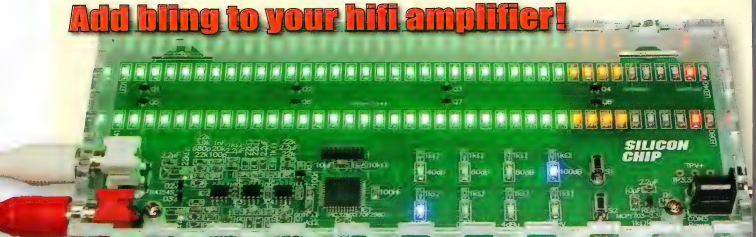
Jan prefers Google Chrome, so I then downloaded and installed that, along with Libre Office, Thunderbird (for email), CCleaner and VLC Media Player. I didn't bother with a third-party anti-virus application. Windows 10 comes with Windows Defender built in and this offers basic protection.

If you want something better, there are plenty of commercial and freeware anti-virus applications available. One of the leading freeware apps is "avast! Free Antivirus" but there are lots of others to choose from (see **www.snapfiles.com/freeware/security/fwvirus.html**)

And that was it. The machine now serves as Jan's "upstairs computer" and has proven to be completely reliable. And Windows 10 runs like it was made for the machine.

So my gamble on the new motherboard paid off but was it all really worth it? Well, yes and no! Yes, because I really enjoyed the challenge of getting it going again and for an outlay of just $100 it's a really good machine. And no, because if this had been a commercial exercise, it would have been completely uneconomic by the time six or seven hours of labour had been added onto the parts costs. **SC**

Add bling to your hifi amplifier!



Pt.1: By Nicholas Vinen

100dB Stereo LED Audio Level/VU Meter

Give your hifi system WOW factor with this spectacular stereo VU meter. It uses 80 high-brightness SMD LEDs to give any stereo amplifier/mixer a highly colourful dual-bargraph display which simultaneously shows the average audio signal level plus peak levels. And it can display signal ranges up to a whopping 100dB.

YEARS AGO, some big and expensive stereo power amplifiers sported large dual VU meters to indicate the power levels in both channels. But while they looked quite impressive, they were a bit of a gimmick since their analog meter movements could only display signal averages. They certainly weren't fast enough to display the peak signal levels which would have been a big advantage.

And of course, professional audio mixing desks also typically have VU metering but these days it is usually based on LED arrays which show average and peak signal levels, just like this new SILICON CHIP design!

The SILICON CHIP Stereo LED VU Meter uses no less than 80 high-brightness SMD LEDs to give a dual bargraph display of the average audio signal level, with dots indicating the peak levels. It can be configured to display a dynamic range between 40dB and 100dB, depending on your application. It's suitable for monitoring line level signals or power amplifier outputs.

Whether or not you actually need to add this meter to a piece of equipment, once you see it in action, you'll want to fit it in anyway! We've put a video of it operating at the following URL so you can see for yourself: **www.siliconchip.com.au/Videos/StereoVUMeter**

If you are a keen hifi enthusiast, this VU meter can show you how much headroom you have from your audio amplifier, ie, it can show how many more decibels it is capable of delivering before clipping and this is indicated with the peak dot display.

It can also be used when recording or mixing, to ensure that the incoming audio signal(s) are consistent with each other and none of them are going to overload and cause excessive distortion or loss of dynamic range.

One important feature of an audio level meter is that it should update relatively fast, so you can see the dynamic nature of the signal, but not so fast that your eye can't track it. Traditional "VU Meters" were designed with a response time of 300ms (to 99%), to give a reasonable impression of signal loudness but also because the needle could only move so fast.

Since this meter uses digital technology, it can show the peak and average level simultaneously and the peak

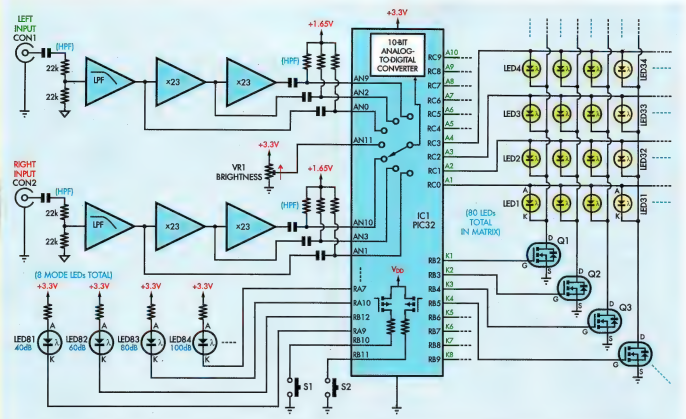


Fig.1: a simplified circuit showing how the Stereo VU Meter works. The audio signals (left & right channels) first pass through a high-pass filter/attenuator, followed by an active low-pass filter and two gain stages. The signals before and after the gain stages are then fed to microcontroller IC1 which does the peak and average calculations, then drives a multiplexed LED display using outputs RB2-RB9 to control eight cathode-driving Mosfets (Q1-Q8) and outputs RC0-RC9 to drive the LED anodes directly.

level can have a fast rise time and a slow fall time. The fast rise-time allows the circuit to "catch" those very fast and short peaks, while the slow fall time allows you to better see them when they occur.

For purists, we've implemented a VU-style meter mode so you can stick with the traditional 300ms rise/fall time averaging if that is what you want.

The two bargraphs, one for each stereo channel, consist of 40 individual LEDs. With a dynamic range of 40dB, that means that each LED lights for a 1dB increase in signal level. If you select the 60dB range, that gives 1.5dB/LED; the 80dB range gives 2dB/LED; and the 100dB range, 2.5dB/LED. These are SMD LEDs with rectangular lenses roughly 2mm square – and they are incredibly bright pin-points. An on-board pot can be set reduce the brightness for a darker room!

We've used a green/yellow/amber/red colour scheme. The colour shifts simply give a warning that you are approaching the clipping level.

A pushbutton can select one of four full-scale signal levels: -10dBV, 0dBV, +4dBu or +7dBV. Different equipment will have different line levels and one of these will suit most devices: -10dBV (316mV RMS) for some battery-powered consumer equipment such as iPods and mobile phones, 0dBV (1V RMS) for other consumer equipment, +4dBu (1.228V RMS) for some professional gear and +7dBV (2.24V RMS) for CD, DVD and Blu-ray players and some other equipment.

You can make fine or coarse adjustments to these levels or set your own levels based on reference signals fed into the unit.

The unit runs from a 12-15V DC supply so it can be powered from a small plugpack, 12V lead-acid battery or a low-voltage internal rail in an amplifier or similar equipment. It only draws about 50-150mA when operating, depending on the LED brightness setting.

The PCB includes RCA input sockets and a DC socket for power, so it can be used in its own case with a clear lid or incorporated into another piece of equipment and hard-wired in place.

The metering circuit's signal-to-noise ratio is good enough to allow you to use the 100dB range with a +7dBV reference level and use the whole range of the device. The 100dB range can also be used with a lower reference level but you will need to use the noise nulling feature to get a blank display with no signal. This feature is especially useful to subtract source noise (eg, from the driving equipment) from the display when operating in the higher dynamic range settings.

Other features include: software adjustments to cancel out variation in brightness between different colour LEDs; peak+average, peak-only and average-only modes; non-volatile mode and calibration settings; and mode indicator LEDs (see specifications panel for more details).

Principle of operation

Fig.1 is a simplified circuit diagram which gives an overview of the operation of the unit. It's based on 32-bit microcontroller IC1 which operates at 40MHz and incorporates a 10-bit

Features & Specifications

- **Display:** two rows of 40 SMD 3216 (1206 imperial) LEDs
- **Input signal:** up to 2.33V RMS (+7.36dBV) or higher with changed resistors (eg, to suit power amplifier outputs)
- **Frequency response:** 5Hz-20kHz, -3dB (see Fig.2)
- **Input impedance:** approximately 37kΩ
- **Modes:** peak+average (dot/bar), average only (bar), peak only (bar), VU-style (peak+average or average only)
- **Meter range:** selectable 40dB, 60dB, 80dB or 100dB (1dB/LED, 1.5dB/LED, 2dB/LED or 2.5dB/LED)
- **Reference level:** selectable -10dBV (316mV RMS), 0dBV (1V RMS), 4dBu (1.228V RMS), 7dBV (2.24V RMS) or custom levels (per-channel)
- **Power supply:** 12-15V DC, ~50-150mA
- **Brightness adjustment:** 10-100% via potentiometer (onboard trimpot or chassis-mounted)
- **Inputs:** RCA sockets for signals, 2.1mm or 2.5mm ID DC socket for power
- **Other features:** LED brightness matching for different colour LEDs in display, external/internal noise nulling, peak/average calculation period adjustment, supply reverse polarity protection

analog-to-digital converter (ADC) with an input multiplexer. Seven of the analog inputs are used.

The two 40-LED bar displays (80 LEDs in total) are multiplexed in eight groups, each group of 10 sharing a common cathode which is driven by one of eight N-channel Mosfets Q1-Q8, which are in turn controlled by the microcontroller's outputs RB2-RB9. The LED anodes are driven directly by outputs RC0-RC9. Only a 4x4 portion of the 8x10 LED matrix is shown but you can see the general arrangement.

The eight indicator LEDs (LEDs81-88, four shown in Fig.1) are driven directly at their cathodes from eight microcontroller outputs. The anodes connect to the 3.3V supply via current-limiting resistors.

Actually, there are no current-limiting resistors for the matrixed LEDs, as such. Instead, their current is limited by the internal impedance of the transistors which drive the micro's output pins, in combination with a software-limited on-time/duty cycle.

This results in a current drive of around 1.2mA/LED at full brightness, for a total LED bar current of around 100mA. Since this is split between 10 anode drive pins, that means around 10mA per pin. (IC1 has an "Absolute Maximum" rating of 15mA/pin and an overall limit of 200mA).

The analog signals are fed into CON1 & CON2 at left. The circuit is designed for line level signals with a maximum level ranging from around 316mV RMS (-10dBV) up to 2.33V RMS (+7.35dBV), to suit most consumer equipment and also some professional audio gear. The input divider resistors can be changed to allow much higher signal amplitudes, eg, to suit the outputs of a power amplifier. Further adjustments in full-scale level can be made using the pushbutton interface.

The signals are AC-coupled and attenuated to no more than 1.16V RMS (3.3V peak-to-peak) using a resistive divider. This AC coupling serves as a high-pass filter (HPF) to remove DC and very low frequency signals (<5Hz). Note that there is another HPF at the ADC inputs of IC1.

There is also an active low-pass 3-pole filter inserted immediately after the resistive divider, built around a dual op amp (for both channels) with a -3dB point of 20kHz. It provides a fast roll-off, with around 20dB of attenuation by 40kHz and also incorporates RF filtering. The overall effect of the low-pass and high-pass filtering on the frequency response is shown in Fig.2.

Analog-to-digital conversion

The signals from the output of the low-pass filters are fed directly to a pair of analog inputs on IC1. These signals are also amplified by 23 times and the amplified signal is fed to another pair of analog inputs. This signal is further amplified by another 23 times (ie, 529 times total) and fed to a third pair of analog inputs. The seventh analog input is used to sense the position of the brightness pot.

The micro samples all seven inputs, with the six signal inputs sampled continuously at around 40kHz and the brightness pot sampled every millisecond or so. For each channel, the software uses whichever signal gives the most accurate reading, ie, the unamplified input for higher level signals and one of the amplified inputs for lower level signals. This greatly improves its dynamic range, given that it only has a 10-bit ADC.

A perfectly noiseless 10-bit ADC would give a dynamic range of around $20\log_{10}(2^{10}) = 60$dB. CD-quality audio uses 16 bits and has a dynamic range of $20\log_{10}(2^{16}) = 96$dB, so it is desirable for our VU meter to have a similar dynamic range.

We could have used an external ADC however these mostly come in fine-pitch SMD packages and can be a little expensive. Instead, we have used the two gain stages described above, in combination with software input switching depending on signal level, to effectively provide the extra bits needed to achieve a 100dB dynamic range while only using the existing 10-bit ADC.

Two momentary pushbuttons, S1 and S2, are used to configured the unit. These can be used to change a variety of settings such as the meter range, reference level, peak/averaging mode, level calibration, brightness calibration and so on. When pressed, S1 pulls input RB10 low while S2 pulls RB11 low. These are held high by internal pull-up resistors which are enabled by the firmware.

In essence, the circuit concept is relatively simple but a lot of the work, including the peak and RMS calculations, averaging, display multiplexing and so on are done by IC1's firmware.

Full circuit description

The full circuit diagram for the Stereo VU Meter is shown in Fig.3. The left and right channel input circuitry is identical so we will describe the left channel only, with part numbers for the right channel in brackets.

From CON1 (CON2), the signal is AC-coupled via a 2.2µF ceramic capacitor and DC biased to +5.6V via a 22kΩ resistor. The 5.6V rail is half the

11.2V op amp supply, allowing the signal to swing symmetrically between the op amp supply rails (ie, between 0V and 11.2V).

This 22kΩ bias resistor forms a divider in combination with the input series resistor, attenuating the input signal by half while keeping the input impedance relatively high at around 37kΩ. As explained later, these resistor values can be changed to allow the unit to handle higher signal levels.

As stated earlier, the 2.2µF capacitor and 22kΩ series resistor form a high-pass filter for the input signal. Further high-pass filtering is also performed by the software.

Dual SMD Schottky diode D2 (D3) clips the input signal, should it go below ground or above the 11.2V op amp supply rail. The BAT54S has a low forward voltage of around 0.3V, so it will conduct before the junctions in the op amp's inputs.

Low-pass filter

The following active 3-pole low-pass filter is built around an NE5532D low-noise op amp IC2a (IC2b). The first section of this filter, consisting of a 3.9kΩ series resistor and 680pF capacitor, also serves to attenuate much higher frequency signals (eg, AM radio) which may have been picked up by the signal leads.

This filter is a special case of the Sallen-Key active low-pass filter (see www.beis.de/Elektronik/Filter/Act-3PoleLP.html) which gives a -18dB/octave roll-off using a single active device (in this case, an op amp). The values were chosen carefully, to give a near-flat bandpass response (ie, Butterworth characteristic) using E24-series resistors and E12-series capacitors (see Fig.2).

Note that the 3.9kΩ resistor was chosen with the 11kΩ impedance of the preceding divider being taken into account. In other words, the resistance between the input and the 680pF capacitor should be 14.9kΩ; the two 22kΩ resistors are effectively in parallel when considering the impedance feeding the RC filter, hence we subtracted 11kΩ from 14.9kΩ to get 3.9kΩ.

The filtered output from pin 1 of IC2a (pin 7 of IC2b) is fed to analog input AN0 (AN1) of microcontroller IC1 via a 2.2µF capacitor and 1kΩ series resistor. This resistor, in combination with dual Schottky diode D4 (D7), prevents the voltage at the micro's input

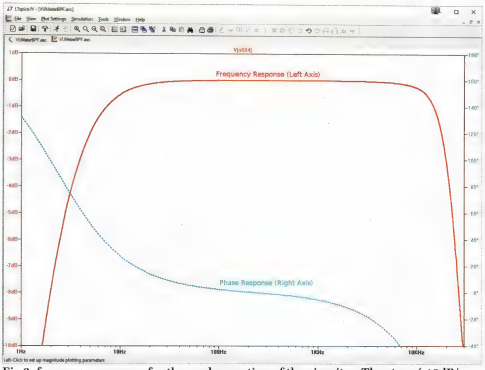


Fig.2: frequency response for the analog portion of the circuitry. The steep (-18dB/octave) roll-off of the low-pass filter can be seen, with virtually no attenuation below 15kHz, -3dB at 20kHz, -10dB at 30kHz and around -20dB at 40kHz (not visible). The bass roll-off is from two passive high-pass RC filters and gives a -3dB point of 5Hz and -10dB at around 1.6Hz.

from going below -0.3V or above +3.6V. In addition, a 22kΩ resistor provides a DC bias of 1.65V, ie, the halfway point of the micro's 3.3V supply. This keeps the signal within the ADC's input range of 0-3.3V for input signals of up to 2.33V RMS (keeping in mind the 2:1 input attenuation).

While the micro has internal clamp diodes to protect its inputs and it might seem like D4 & D7 are overkill, we discovered an interesting "feature" of the PIC32 series – if you drive an analog input pin beyond its supply rails, even within its input current rating, the chip may reset! Hence these clamp diodes are mandatory and as before, Schottky diodes are used because they will conduct before the IC's internal semiconductor junctions.

Gain stages

IC3a (IC3b) and IC4a (IC4b) are both configured as non-inverting amplifiers with a gain of 23, set by the ratio of the 22kΩ and 1kΩ feedback resistors. A 100pF capacitor across the 22kΩ resistor rolls off its frequency response, reducing high-frequency noise gain and making the whole circuit quieter.

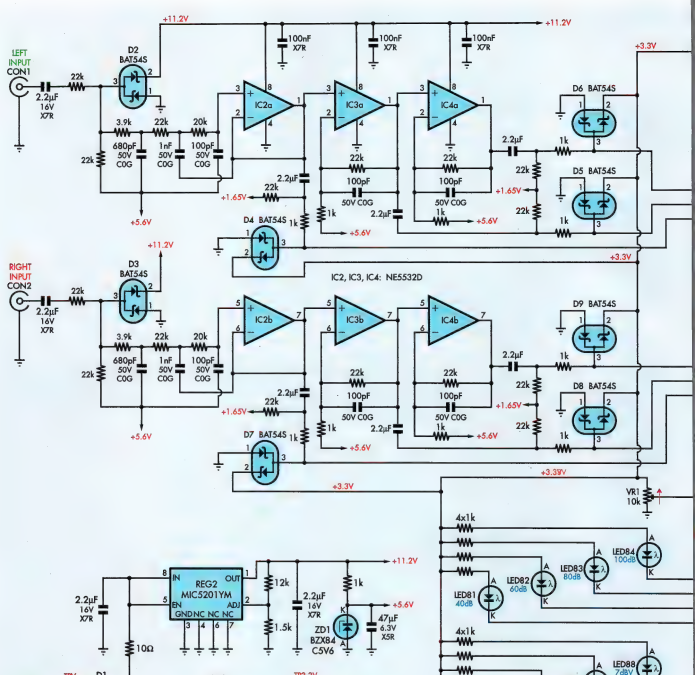
To achieve the 100dB dynamic range relative to 7dBV (2.24V RMS), we need less than 22.4µV RMS input-referred noise throughout the entire system. That is why we're using NE5532 low-noise op amps.

The total gain of the system from the input to analog input AN9 (AN10) is 0.5 x 23 x 23 = 264.5 times. A -100dB (2.24µV) input signal will thus be amplified to 6mV RMS. The 10-bit ADC can sense voltage steps of 3.3V ÷ 1024 = 3.2mV. So this level of signal can be (just) measured by IC1.

Driving the LEDs

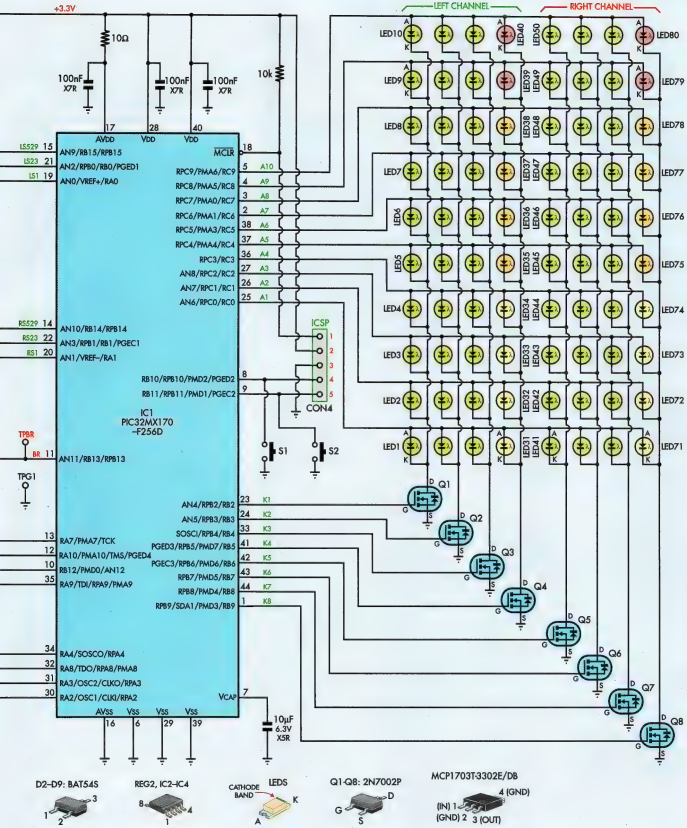
Driving the 80 LEDs in the VU meter takes up a total of 18 output pins. Each bar of 40 LEDs is broken up into four groups of 10 and the cathodes of the LEDs in each group are tied together. These cathodes are driven by one of logic-level Mosfets Q1-Q8 which are in turn driven from microcontroller outputs RB2-RB9 (pins 23, 24, 33, 41-44 and 1 of IC1 respectively). Because these Mosfets have such a small gate charge, no extra circuitry is required. Each Mosfet is switched on in turn for around 1.6ms.

When Q1 is switched on (ie, pin 23 of IC1 [RB2] is high), LED1-LED10 can be lit when their respective anodes are driven high. The anodes are driven by outputs RC0-RC9 of micro IC1 (pins 25-27, 36-38 & 2-4 respectively).



DIGITAL STEREO AUDIO LEVEL/VU METER

Fig.3: full circuit for the Stereo VU Meter. This shows the full 80-LED matrix at right, along with the power supply and details of the analog circuitry. Dual Schottky diodes D2 & D3, in combination with the 22kΩ series resistors, protect IC2 from excessive input signal levels while D4-D9 (with 1kΩ series resistors) prevent IC1's internal input clamp diodes



from conducting, depending on the signal applied. Also shown in more detail on this diagram are the three different signal bias levels of 0V (GND), 1.65V (half supply for 3.3V) and 5.6V (half supply for 11.2V). The amplified and filtered input signals are fed to microcontroller IC1 which drives the LED bargraphs via Mosfets Q1-Q8.

Simulating VU Meter Response

The adjacent photo shows an original VU meter. According to Wikipedia: "The original VU meter is a passive electro-mechanical device, namely a 200µA DC d'Arsonval movement ammeter fed from a full-wave copper-oxide rectifier mounted within the meter case. The mass of the needle causes a relatively slow response,

which in effect integrates the signal, with a rise time of 300ms. 0 VU is equal to +4dBu, or 1.228V RMS across a 600-ohm load . . ."

The Silicon Chip Stereo LED VU Meter does not attempt to exactly replicate the operation of a VU meter. For example, the copper-oxide rectifier causes a VU meter to be inaccurate for low-level signals and thus makes a reading below -20dB difficult. We're still using proper RMS calculations and showing readings on a range of at least 40dB (depending on the range setting of the unit).

However, we have been able to implement a simulation of the ballistic properties of the VU meter needle in our software. When a 1 kHz sinewave is applied to a standard VU meter which had previously had no signal applied, it should reach 99% of the final reading in 300ms and have an ultimate overshoot of between 1% and 1.5% of the reading. We've achieved this with a simple needle inertia simulation that tracks the needle position and velocity along with a target position (based on the current RMS reading), an acceleration coefficient and a damping coefficient. These two coefficients were tuned to achieve the required response, as stated above.

The cathodes of LEDs81-88 are driven by microcontroller outputs RA9, RB12, RA10, RA7, RA8, RA3, RA2 and RA4 respectively (pins 35, 10, 12, 13, 32, 31, 30 and 34). The 1kΩ current-limiting resistors result in a drive of around 0.5mA each.

Controls

Tactile pushbutton switch S1 is used to cycle through the available meter ranges (and performs other functions when pressed and held or pressed in combination with S2). Similarly, switch S2 cycles through the four different reference levels. Their associated input pins, RB10 and RB11 (pins 8 & 9), are also used for programming and debugging IC1. There is no conflict as long as neither switch is pressed when the in-circuit serial programming (ICSP) tool plugged into CON5 is being used.

Brightness pot VR1 forms a voltage divider across the 3.3V supply and the voltage at its wiper is sensed via analog input AN11 (pin 11) of IC1. The brightness is controlled by adjusting the LED matrix anode drive period.

Power supply

The power supply is relatively simple and uses only linear regulators but its design is critical to achieve the stated performance. 12-15V DC is applied to socket CON3, or else wired directly between TPV+ and TPG1.

Schottky diode D1 provides reverse polarity protection and drops less than 0.4V. The 11.6-14.6V DC at its cathode is fed to two resistors. One is a 33Ω 1W SMD type which connects to the input of 3.3V low drop-out (LDO) regulator REG1. This is in a relatively large SOT-223 4-pin package that is soldered to a considerable copper area which includes thermal vias to conduct heat to the back of the board.

With a 14.5V input, 3.3V output and maximum load of 125mA, these components dissipate (14.5V – 3.3V) x 0.125A = 1.4W. Around 0.5W will be dissipated in the resistor with the remaining 0.9W in the regulator, hence the copper plane heatsinking on both sides along with thermal vias under the regulator package.

SMD multi-layer ceramic capacitors are used bypass the input and filter the output of REG1. As well as supplying the microcontroller and LEDs, the 3.3V output flows through a pair of series-connected 3.9kΩ resistors to generate the 1.65V rail, which is bypassed with a 47µF capacitor. This is important since the varying current demand on the 3.3V rail as LEDs are switched causes ripple and we don't want this to couple into the input signal path.

The 11.6-14.6V at the cathode of D1 also flows to adjustable low dropout regulator REG2 (MIC5201). The 10Ω series resistor forms a low-pass filter in combination with its 2.2µF input bypass capacitor to reduce the amount of ripple reaching REG2. It also causes a voltage drop of up to 0.25V.

REG2's output is set at 11.15V (nominal) by the 12kΩ and 1.5kΩ resistors. REG2's minimum input voltage is around 11.6V – 0.25V = 11.35V. With a load current of only 25mA, REG2's dropout voltage is less than 150mV, so it should stay in regulation. This is important since REG2 exists to eliminate ripple on the op amp supplies; even with a 100dB CMRR (common mode rejection ratio), several hundred millivolts of ripple can have a significant impact on the overall signal-to-noise ratio of the system.

The 5.6V half-supply reference for the op amps is derived from the 11.2V supply with a 1kΩ resistor and 5.6V zener diode ZD1, which is bypassed with another 47µF capacitor. This further attenuates any ripple which may make it through the regulator.

Microcontroller IC1 has three 100nF ceramic supply bypass capacitors, with its AVCC supply filtered by one of these in combination with a 10Ω series resistor. A 10µF ceramic capacitor between pin 7 (VCAP) and ground provides an output filter for its internal 2.5V core regulator, while a 10kΩ pull-up between the 3.3V rail and pin 18 (MCLR-bar) prevents spurious resets.

PCB layout

The PCB design is crucially important to achieve the desired performance level. The relatively compact PCB means that the switched LED supply lines inevitably run somewhat near the front end and the tiny amount of signal that couples in is picked up and amplified by the op amps. This is mostly ignored by the software (as explained later) but it does make the noise level in the left channel slightly worse than the right (but still below -100dB) due to its greater proximity to the LEDs.

The most critical part of the layout, as is typical, is the ground track routing. While all points connected to ground in the circuit must be joined together, there are a large number of ways this could be achieved, many of which would cause digitally switched

currents to cause voltage shifts across different parts of the analog front-end, ruining the performance.

The grounds for input sockets CON1 & CON2, regulators REG1 & REG2 (and their output filter capacitors but NOT input bypass capacitors) and the bottom end of the two half-rail bias generators are connected together, then brought back to pin 16 of IC1 (AGND). This pin is also used as the negative reference voltage for the ADC. This routing means that the analog grounds and half-supply rails have very little AC voltage between them, as little current flows through these tracks and that which does is linearly proportional to the input signal.

AGND is connected to GND within IC1, and also by tracks running under it, so ultimately these pins all connect to GND. The op amp negative supply pins and their bypass capacitors are connected back to the ground pin of REG2 and the more-or-less constant supply current flows from there back to AGND and on to the main ground network.

Firmware operation

While the software is conceptually simple, it has quite a few modes and features. Its three main tasks are to continually sample the analog inputs, perform the average and peak calculations based on the results and drive the multiplexed LED display. The first and last are "real time" tasks so they are interrupt driven, with priority given to the LED multiplexing, as any delays could cause the display to flicker.

The LED multiplexing is achieved using three of the five 16-bit timers internal to IC1: Timer1, Timer2 and Timer3. IC1 runs at 40MHz, in order to perform the required calculations fast enough to provide a rapid display update (around 40 updates per second). Timer1 is set up to trigger an interrupt every 65,536 (2^{16}) clock cycles, ie, every 65,536 ÷ 40MHz = 1.6384ms. Since there are eight cathodes to cycle through, this gives a display refresh rate of 76Hz.

When this interrupt is triggered, the code branches to the Timer1 interrupt handler, which switches the LED anode drive outputs (RC0-RC11) low, then cycles the next Mosfet drive output (RB2-RB9) high. It then calculates which anodes to drive to light the appropriate LEDs and brings some combination of RC0-RC11 high.

If the brightness trimpot is set at a level below 100%, before the interrupt handler completes, it enables Timer3 and sets it for a value proportional to the brightness. When the interrupt handler for Timer 3 is subsequently triggered, RC0-RC11 are brought low, cutting off the LED drive to reduce the

Parts List

1 double-sided PCB, code 01104161, 177 x 75.5mm
1 white switched PCB-mount RCA socket (CON1)
1 red switched PCB-mount RCA socket (CON2)
1 PCB-mount switched DC socket, 2.1 or 2.5mm inner diameter (CON3)
1 5-pin header, 2.54mm pitch (optional, to program IC1) (CON4)
2 PCB-mount mini tactile switches (S1,S2) (Jaycar SP0611)
1 10kΩ SMD trimpot, TC33X type (VR1) (element14 1689863)
5 PC stakes (optional; see text)
1 12-15V DC 150mA+ power supply

Semiconductors

1 PIC32MX150F128D-I/PT or PIC32MX170F256D-I/PT 32-bit microcontroller programmed with 0110416A.hex, TQFP-44 (IC1)
3 NE5532D dual low-noise op amps, SOIC-8 (IC2-IC4)
1 MCP1703-3302E 16V in, 3.3V out, 250mA low-dropout regulator, SOT-223 (REG1)
1 MIC5201YM 20V, 200mA adjustable low-dropout regulator, SOIC-8 (REG2)
8 2N7002P logic-level N-channel Mosfets, SOT-23 (Q1-Q8)
1 BZX84C5V6 5.6V 1/4W zener diode, SOT-23 (ZD1)
1 30V 1A Schottky diode, SMA/DO-214AC or Mini2 SMD package (D1)
8 BAT54S dual series Schottky diodes, SOT-23 (D2-D9)
60 high-brightness green SMD 3216/1206 LEDs (LED1-30, LED41-70)
8 high-brightness yellow SMD 3216/1206 LEDs (LED31-34, LED71-74)
8 high-brightness amber SMD 3216/1206 LEDs (LED35-38, LED75-78)
4 high-brightness red SMD 3216/1206 LEDs (LED39-40,LED79-80)
8 high-brightness blue SMD 3216/1206 LEDs (LED81-88)

Capacitors (SMD 2012/0805 unless specified)

2 47µF 6.3V X5R 2012/0805 or 3216/1206
2 10µF 6.3V X5R 2012/0805 or 3216/1206
11 2.2µF 16V X5R
6 100nF 50V X7R
2 1nF 50V C0G
2 680pF 50V C0G
6 100pF 50V C0G

Resistors (SMD 2012/0805, 1% 0.125W unless specified)

2 22kΩ or 22.1kΩ 1% 0.5W 3216/1206
14 22kΩ
2 20kΩ
1 12kΩ
1 10kΩ
4 3.9kΩ
1 1.5kΩ
19 1kΩ
1 33Ω 5% 1W 6331/2512
2 10Ω

Optional parts

Tapped spacers and M3 machine screws for mounting, shielded cable and twin-lead for hard wiring, case with clear lid

Optional laser-cut case

1 set 3mm clear acrylic pieces
1 small tube acrylic glue (solvent-based)
4 M3 x 10mm machine screws
2 M3 x 12mm tapped Nylon spacers
4 M3 shakeproof washers

Where to buy parts

The PCB, programmed microcontroller, case pieces & red/white RCA sockets are available separately from the Silicon Chip Online Shop. We're also offering a set of parts containing all the SMDs except for the microcontroller & LEDs. Sets of 10 red, amber, yellow, green or blue high-brightness 3216-size SMD LEDs with diffused lenses are available separately, so that constructors can choose their own colours.

Handling Higher Amplitude Signals

As presented, the circuit is designed to accept sinewave signals up to 2.33V RMS (6.6V peak-to-peak or 3.3V peak). Signals above this level will cause D2 & D3 to conduct and the meter will simply show a full -scale reading but no damage should occur.

This is not sufficient to monitor the outputs of a power amplifier. Some equipment may also produce line-level signals above 2.33V RMS. In this case, it's simply a matter of changing the input divider so that, with the maximum input signal level, the resulting voltage does not exceed 3.3V peak-to-peak. The parallel combination of the two divider resistors should be kept to 11kΩ. This means that the "lower" leg resistor will need to be reduced in value, probably to somewhere in the range of 11-15kΩ.

Consider a power amplifier like our Ultra-LD Mk.4 (August-October 2015) which can deliver 135W into 8Ω or 200W into 4Ω. This requires an output voltage of √(135 x 8) = 33V RMS or 93V peak-to-peak (33V x 2.828). For 200W into 4Ω, the output will be √(200 x 4) = 28.3V RMS. So the meter would need to handle 33V RMS to monitor the outputs directly.

This means a divider ratio of at least 93V ÷ 3.3V = 28.2 is required. We set the bottom leg to 11kΩ (ie, the resistor from the 5.6V rail) since the other resistor value will be much larger and have negligible contribution to the divider's output impedance. The other resistor will then need to be at least 11kΩ x (28.2 – 1) = 300kΩ. This happens to be an E24 value; if it wasn't, we would have chosen the next higher value. The parallel resistance is 1 ÷ [(1 ÷ 11kΩ) + (1 ÷ 300kΩ)] = 10.6kΩ, which is close enough to 11kΩ.

This new divider reduces the input levels by 23dB compared to the original design, so the +7dBV setting is in reality now +30dBV, which would indicate full amplifier power into 8Ω. Note that the other reference levels will be effectively increased by the same amount.

average display brightness. Both interrupt priorities are set to level four, the highest used.

An error in the silicon?

This multiplexing method works very well, giving a stable and bright display. At least, it did until we enabled the ADC. Even with ADC interrupts disabled, it caused the LED display to flicker.

We couldn't understand why, since the timer period should not be affected by the operation of the ADC and the flickering occurred even without enabling interrupts for the ADC unit at any location in the code. So why should the ADC interfere with the multiplexing?

We got a clue by examining the Mosfet drive signals for Q1-Q8 using an oscilloscope. Periodically, one of the Mosfet gate drive pulses would be extremely short; rather than the expected 1.6384ms, it measured something like 50µs, appearing as just a spike on the screen. Following that occurrence, the next pulse for that same Mosfet would occur about 11.5ms later, or roughly seven timer periods, rather than the expected 13.1ms (eight timer periods).

This pointed to the possibility that, having completed the Timer1 interrupt handler, the processor would sometimes immediately re-enter it and thus the code would then assume some time had passed and switch to the next multiplexed bank of LEDs prematurely. For some reason, this occurred only when the ADC was enabled and active. We can't figure out how the software could have caused this, since when the ADC is in auto-sampling mode, with interrupts disabled, it operates autonomously.

Simple solution

In the end, we came up with a simple solution: we set Timer2 to the same time base and period as Timer1. When the Timer1 interrupt handler is about to exit, it resets Timer2. At the start of the Timer1 interrupt handler, we check the value of the Timer2 counter. If it's less than half the expected value, indicating that the Timer1 interrupt should not have occurred yet, we exit the interrupt handler without doing anything. This allows us to ignore the occasional spurious event.

Our guess as to the nature of this problem is that an implementation bug in this series of PIC32s causes some interrupt handlers to re-triggered upon exit if something else is going on in the chip simultaneously.

A "gotcha"

Another issue we ran into is that the display also started flickering when we added the code to update the states of LEDs81-88. Unlike the previous issue, this turned out to be our fault. LED86 is driven by output RB12 which is on the same port as the pins driving Mosfets Q1-Q8 (ie, RB2-RB9).

The code to update the state of LED86 read:

```
LATBbits.LATB12 = !(Sensitivity == 1);
```

This looks like an atomic operation, setting the bit LATB12 which controls the state of output RB12. However, it is actually a read-modify-write operation, ie, the value of special register LATB is transferred to a general purpose register, the value of bit 12 is changed and the result is then transferred back to the special register.

But if the Timer1 interrupt handler is triggered in the middle of this procedure, it may change the value of special register LATB. When the special register is written back later by the above code, that overrides the change made by the interrupt handler.

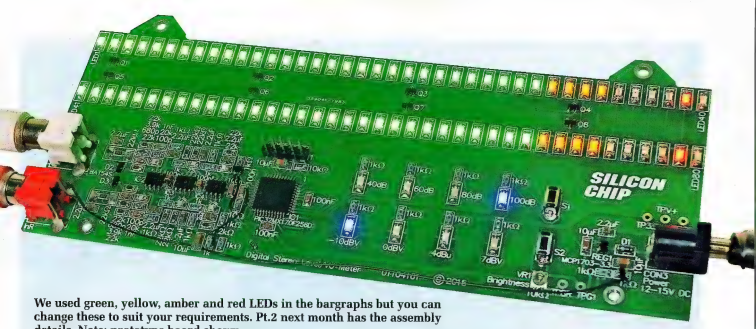
One possible solution is to temporarily disable interrupts while updating LATB12 but that's clumsy. The elegant solution is to take advantage of the special set/clear/toggle registers available for all the GPIO registers (and many others) on this chip, ie:

```
if( Sensitivity == 1 )
  LATBCLR = 1<<12;
else
  LATBSET = 1<<12;
```

These operations are atomic, ie, can't be interrupted. If an interrupt handler is triggered simultaneously, it will be executed either before or after the clear/set operation, eliminating the flicker.

Analog computations

As explained earlier, the input signals (left & right channels) are applied to six different analog inputs: two with an overall gain of one half, two with a gain of 11.5 times and two with a gain of 264.5 times. However, rather than switch between sampling these different inputs depending on signal level, we simply sample all six, all the time. The code in the ADC conversion



We used green, yellow, amber and red LEDs in the bargraphs but you can change these to suit your requirements. Pt.2 next month has the assembly details. Note: prototype board shown.

complete interrupt handler routine decides which to use, depending on the values returned.

If the value from the input amplified by 264.5 times is very near either rail (ie, the conversion result is very close to either zero or 1023), the value from the 11.5 times amplified input is used instead, multiplied by 23 so that it has the same scale as readings from the other input. If that lower-gain input is also found to be very near either rail, the value from the third, attenuated input is kept instead, multiplied by 529 (23 x 23). The result is then stored in one of two 1024-entry stereo buffers for later analysis, to keep the interrupt handler routine quick so it won't interfere with LED multiplexing.

The micro's peripheral clock is set to run at half the rate of the main clock, ie, 20MHz. The ADC clock input divider is set to a factor of two, giving 10MHz. Each conversion takes 12 cycles, plus eight cycles for the sample-and-hold buffer to stabilise, for a total of 20 cycles each (10MHz ÷ [20 x 6] = 83.3kHz). We average each pair of sample values to reduce system noise, resulting in a final sampling rate of 41.6kHz, sufficient for measuring signal frequencies up to 20.8kHz (the Nyquist limit).

Once a sample buffer is full, the code's main loop calculates the average of all values and subtracts it from the sample values to remove any DC offset or low-frequency signals which have not been rejected by the analog filter. It then computes the RMS and peak values for each channel.

The resulting RMS values are then stored and averaged over a configurable number of 1024-sample intervals, so that it varies smoothly. Similarly, the highest peak values across multiple 1024-sample buffers are computed.

These RMS and peak values are converted into decibels using a logarithmic calculation, taking into account the current range and reference level selection. The display is then updated to show the peak and/or average results (depending on the display mode).

Other functions

Button presses are sensed using a pin change interrupt and debounced using Timer4 (S1) or Timer5 (S2). When a press is detected, the interrupt handler sets a flag and the main loop updates the mode and then saves the new setting to flash memory. These saved settings are automatically loaded each time the unit is powered up.

Long presses (>0.5s) have a different effect compared to short presses and this is determined by when the associated timer rolls over. As well as using these buttons to change the display range and reference level, various combinations can be used to change settings, to be described next month in Pt.2.

Noise nulling is implemented by storing the left and right channel RMS and peak values when S1 is held down, both in RAM and flash memory. These are subtracted from subsequent readings, with the RMS noise figure being subtracted in an RMS manner.

That's all we have space for this month. Next month we'll get onto the PCB construction, testing, operation and fitting the unit into a case. SC

LED Colours

In our prototype, we used 30 green LEDs at the left end of each bargraph, followed by four yellow, four amber and two red. This is a purely aesthetic choice. You could make them all the same colour (eg, blue), or use a different combination than we did.

While brightness matching between different colours is generally good enough, the software allows you to provide some drive compensation to reduce the difference in apparent brightness between different colour LEDs.

We also decided to make LEDs81-88 blue, in contrast to LEDs1-80 and the parts list reflects our choices.

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The view at left shows the cooling system monitor in operation while the above photo shows the radiator and cooling fan assembly that was added to the stock laser cutter. The air assist pump is behind the radiator in the background, while the water pump is in the water reservoir out of picture to the left (see photo on facing page).

By Nicholas Vinen

Arduino cooling system monitor for a laser cutter

This unit is based on a small Arduino module and monitors the cooling system in a large laser cutter. It monitors the speed of the fans, the water flow and temperature and sounds an alarm in the event of a malfunction, so the operator can take action before any damage occurs. Although designed for a laser cutter, it would suit a number of similar applications.

LASER CUTTERS are now available at quite reasonable prices from China but in line with their modest prices, they do require quite a bit of work to get them up and running, in our experience. In our case, the supplied cooling system was quite rudimentary, consisting of nothing more than an aquarium pump and a couple of hoses. The instructions were to the effect that the pump should be submerged in a large bucket of water and arranged to deliver water to the laser tube which would then flow back into the bucket; not the engineered solution we would expect.

Nor was the arrangement to exhaust toxic fumes from the cutter well sorted out, as it came with a very noisy centrifugal fan which actually leaked fumes, while the large cutter housing itself had multiple air leaks, all of which had to be sealed off. And there were other problems with the assembly which required attention.

Fortunately, the laser cutter itself actually works very well.

As for the rudimentary cooling system, a bucket of water obviously has a limited capacity to absorb heat and as the water gets hotter, the laser performance drops. So we decided to modify the system to incorporate a metal radiator with fan-forced air cooling to keep the laser tube operating at a reasonable temperature long-term, especially in the hotter months.

We selected a copper-cored radiator designed for computer water cooling,

The water reservoir (clear container) and the radiator/fan assembly sit on a platform at the bottom of the laser cutter. Together with the pump, they keep the temperature of the water circulating through the laser tube to about 35°C.

teamed with three 120mm brushless fans. However, we were concerned that if the pump failed, or its power cable somehow became disconnected or a hose leaked, there would be no obvious sign until the laser tube was destroyed. So we decided to include sensors to monitor the fans and coolant flow and provide a water temperature display.

Cooling system upgrades

The parts list shows the items we used to upgrade the cooling system, with the electronic parts listed separately. Besides the electronic components, pretty much everything was purchased via the www.aliexpress.com website. Some would no doubt be available from plumbing supply stores or specialist computer stores but we liked the convenience of ordering them all in the one place.

Most of these parts were used to plumb the radiator, which has British Standard Pipe (BSP) G1/4" female connection points, into the existing laser cutter cooling system which used 8mm ID silicone tubing pushed onto hose barbs.

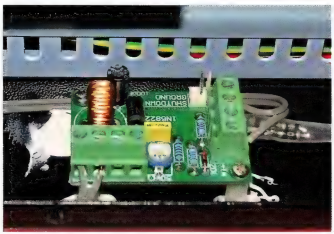
The T-fitting was attached to the inlet end of the radiator to allow the G1/8" threaded temperature sensor to be screwed in (via an adaptor), to monitor the temperature of the water coming from the laser tube. The G1/2" flow sensor was connected to the radiator outlet via an elbow fitting and G1/4" to G1/2" adaptor. A flow sensor with G1/2" fittings was chosen as it was thought that this would provide less flow resistance than a G1/4" fitting flow sensor with much smaller internal passages.

The electronics and fans run from 12V. The laser cutter has a 24V + 5V power supply, so we used the MiniSwitcher (Simple 1.2-20V 1.5A Switching Regulator, February 2012) to efficiently convert 24V to 12V.

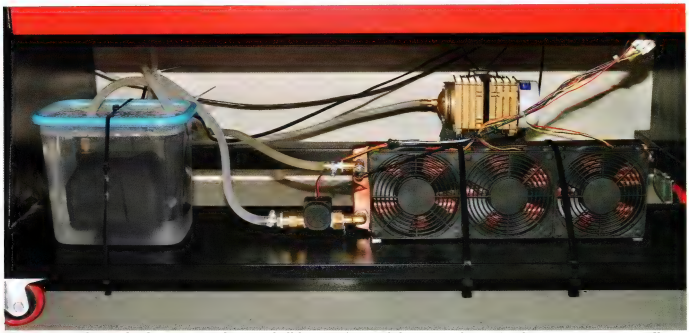
The photo below shows the MiniSwitcher board glued into the laser cutter chassis with white silicone sealant. One grey figure-8 lead brings 24V power from the laser cutter supply and another routes the 12V output up through the chassis to the control box on top.

Electronic module

The control box is based on a tiny Arduino board (a "Pro Micro"). The circuit is shown in Fig.1, along with some of the plumbing details. Its job is to control and monitor the fan speed and also monitor the water flow. If the speed of any fan or the water flow rate drops below a predefined threshold (80% of nominal), red LED3 lights and a piezo transducer beeps.



The MiniSwitcher power supply board was glued onto a shelf inside the laser cutter chassis using white silicone sealant.



The copper radiator, the three 120mm-diameter ball-bearing fans and the various brass plumbing accessories were all purchased from www.aliexpress.com The fans are all controlled by an Arduino module in the Cooling System Monitor.

Warning yellow LED2 lights if the fan speed or water flow rate drop below 90% of the nominal rates, indicating a possible pending failure, blockage or perhaps pinched off water tube. Otherwise, if everything is OK, green LED1 lights to indicate that it is operating normally.

The temperature display unit is powered from a 12V output on the control module (CON3) and sits on top of it.

Circuit description

MOD1 is an Arduino "Pro Micro" board based on the ATmega32U4. This is very similar to the LeoStick module from Freetronics that we reviewed in July 2012, and is available from Jaycar. The main difference is that the Leostick plugs into a USB port directly while the Pro Micro is a little smaller and has a MicroUSB socket instead.

The Pro Micro comes in 3.3V and 5V versions; we used the 5V version. In this application, the USB connection is used only for initial programming so we decided it would be better to use the smaller Pro Micro.

The software could be adapted to just about any Arduino board. Since the LeoStick uses the same processor, it would probably work without any changes but we haven't tried it.

MOD1 senses the position of fan speed control pot VR1 which is connected across the micro's 5V supply. The voltage (0-5V) at its wiper is sensed by the Arduino's A6 ADC input at pin 7. Depending on the voltage sensed, it produces a 50-100% duty cycle PWM waveform at output D10 (pin 13) which drives the gate of N-channel small signal Mosfet Q2.

When Q2's gate is driven high, it switches on and pulls Q1's gate low. Q1 is a P-channel Mosfet so this switches on in turn, allowing current to flow from the 12V supply at CON1, through reverse polarity protection diode D1, polyswitch PTC1, Q1, inductor L1 and to the fans.

PTC1 provides short-circuit protection; in the case of a short across the fan supply, it will rapidly heat up and its resistance then increases, limiting the maximum current to around 1A.

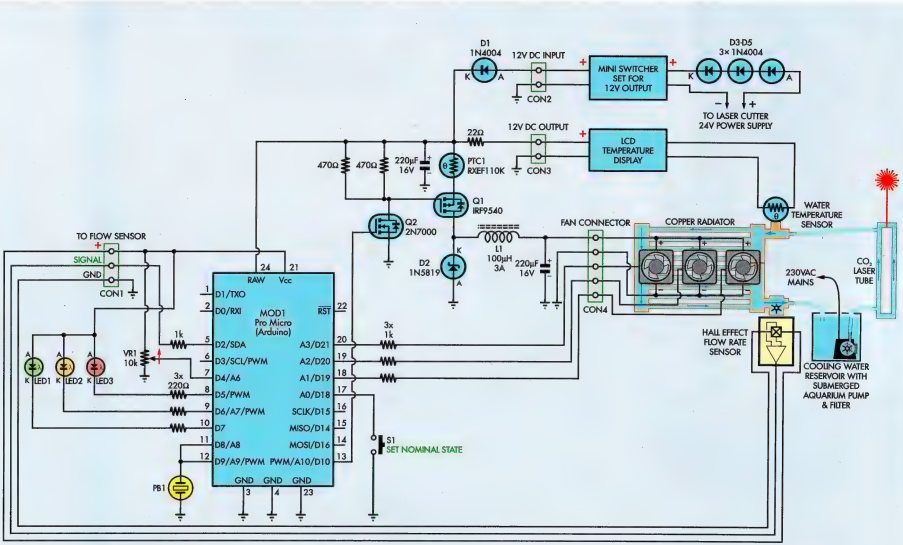
When pin 13 of MOD1 goes low, Q1 switches off and the two parallel 470Ω 0.5W resistors pull up Q1's gate to its source voltage, switching it off. This cuts off the current supply for L1, however its magnetic field is still initially charged and this causes current to flow from ground, through Schottky diode D2, inductor L1 and the fans. The 220µF output capacitor also provides current to the fans for the period that Q1 is off.

These two phases are repeated as the PWM signal toggles and this forms a basic buck regulator. What this means is that the voltage across the fans varies smoothly as a function of the PWM duty cycle from pin 13 of MOD1. With VR1 at a minimum setting, the duty cycle is 50% (and the frequency is around 50kHz), giving around 6V across the fans, resulting in slow but steady operation. As VR1 is rotated clockwise, the duty cycle rises to 100%, increasing the voltage at the fans to the full supply, ie, around 11.4V.

Each fan has a Hall effect sensor with an open-collector output and these are wired back individually to inputs D19-D21 (pins 18-20) of MOD1. MOD1 has weak internal current sources enabled for these pins to pull them up, so they are held at 5V unless the fan sensor is pulling them low. MOD1 uses an internal 1-second timer to count the number of pulses per second on each of these inputs, with software debouncing to eliminate spikes that may be due to electrical noise picked up by the wires.

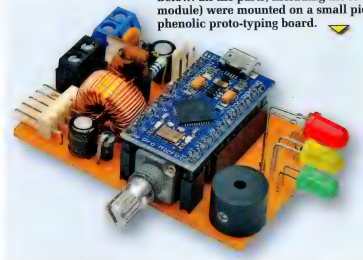
Thus, it can sense the speed of each fan and sound an alarm if any of them drops too low. In this case, the duty cycle from pin 13 is automatically increased to 100% so that if one fan (or the wiring to it) fails, the others will run at full speed to provide adequate radiator cooling until the situation is rectified.

The same method is used to check the output of the Hall effect sensor in the water flow meter, which is connected to input D2 (pin 5). Note that all four sensors are connected via 1kΩ series resistors. These are not strictly necessary when interfacing to devices with open-collector outputs but it protects MOD1 in case of an accidental short of one of the sensor wires to a higher

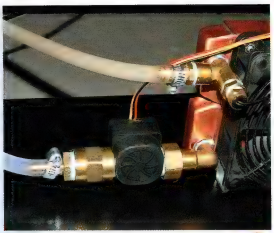


LASER CUTTER COOLING SYSTEM MONITOR

Fig.1: complete circuit diagram for the cooling system monitor. It's based around "Pro Micro" Arduino module MOD1 and monitors the speed of three fans plus the water flow rate. Radiator input water temperature is displayed on an LCD while fan speed is controlled with a simple switchmode circuit comprising Mosfet Q1, Schottky diode D2 and inductor L1.



Below: all the parts, including the Arduino module) were mounted on a small piece of phenolic proto-typing board.



Above: this close-up view shows the flow sensor. It's connected to the sensor circuit via a 3-wire cable (two for the supply and one for signal).

voltage source (eg, 12V or 24V) or in the case of static discharge.

The three status LEDs are driven from outputs D5-D7 (pins 8-10) with 220Ω current-limiting resistors, setting the LED current at around 12mA each. We used high-brightness LEDs with diffused lenses and wide viewing angles so they are highly visible.

The piezo transducer is driven from paralleled outputs D8 & D9 (pins 11 & 12) so that the micro can provide sufficient current for it. It's pulsed with a 25% duty cycle at 2Hz whenever the red LED is lit (ie, if any sensor indicates a rate less than 80% of nominal).

Nominal rates are set using pushbutton S1 which is accessible via a hole in the front of the unit, with a small screwdriver. Like the Hall effect sensor inputs, D18 (pin 17) has a weak pull-up current enabled so that the unit can detect when the button is pressed. When this happens, the current readings for all four sensors are stored in EEPROM, as the nominal readings. The warning and alarm levels are then based on these readings. Since EEPROM is non-volatile, they are retained even when power is lost.

Temperature display

Rather than building a temperature display, we used an automotive threaded brass temperature sensor which connects to an LCD panel, the pair available for around $10, again from AliExpress (see parts list). There are various different-sized threads available and we asked for the "10mm" type which is actually BSP G1/8" (nominal outer thread diameter 9.728mm). Note that BSP sizes indicate the diameter of pipe a given thread is designed for, not the thread diameter itself.

Happily, the two-conductor sensor wire provided was long enough to route it from the radiator input pipe, through the laser cutter and up to the control box. The only connection between the temperature monitor and the control box itself is the 12V power.

As shown in the accompanying photos, the display shows the temperature in degrees Celsius with a 0.1°C resolution, along with a digital "needle" pointing to a temperature scale. It is easy to read, although if your head is above or below the eye-line of the display it looks a bit washed out.

Building it

All the components were fitted to a piece of phenolic prototyping board (with copper donuts, not tracks), with a pair of female headers to connect to MOD1 (which came with male headers). The program was loaded using a MicroUSB cable before MOD1 was plugged into this board.

The accompanying photo shows the basic layout of the parts on the board; note that some of the smaller passive components (eg, resistors) were mounted under MOD1 to save space. Basically, we cut a piece of board 22 x 14 holes wide, soldered the two female headers for MOD1 in place about one third of the way across the board, then proceeded to solder resistors with their leads directly adjacent to the pins on MOD1 to which they had to be connected. We then bridged the leads to the pins using solder.

We then fitted the connectors to the far end of the board and the switch-mode regulator components in between, with the pushbutton, LEDs and piezo at the opposite end, which would become the front of the unit. Where possible, component leads were bent over and soldered directly to the pad for the component they connect to. Where this wasn't possible, we ran point-to-point wiring on the underside of the board, primarily with Kynar (wire-wrap wire).

The board was then powered up, programmed and tested.

Custom case

We used the laser cutter to make a

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	2	470Ω 5%	yellow violet brown gold	not applicable
❑	3	220Ω	red red brown brown	red red black black brown
❑	1	22Ω	red red black brown	red red black gold brown

small custom case, with holes in the front for the LEDs, access to S1 and to allow the piezo transducer to be audible. There's also a hole in the side for VR1's shaft and four small holes at the rear for the power input lead, power lead to the temperature display, fan power/sensing cable and water-flow meter cable.

The leads were fed through the holes in the case and the case glued around the board. If we ever need to get it out, we will have to destroy the case but, of course, as long as we keep the files, we can always cut a new one.

Software

Because the software has a simple, dedicated task, hardware counters and interrupts are not used. Instead, Timer3 is set up to provide a 1-second timebase and the main loop debounces the four frequency inputs at pins D2, D19, D20 & D21 and then counts the number of pulses received at each input per 1-second timer period. These are compared to reference numbers stored in EEPROM and the appropriate LED is lit depending on whether any of these are below 90% of the nominal value (or 80% for the red LED).

If S1 is pressed, the counter values from the last period are stored in those EEPROM values as the future nominal values and the EEPROM is read at power-on and loaded into RAM for comparison.

Each time through the main loop, the analogRead() function is used to determine the voltage at analog input pin A6 and hardware Timer1 is used to produce a PWM signal at output pin D10 which is proportional to this.

The software, being quite straightforward, is quite easy to read. For more details, download the "sketch" and examine the .ino file. We used two Arduino extension modules, "TimerOne" and "TimerThree", to make setting up and using the hardware timers easier.

The Arduino sketch can be downloaded from the SILICON CHIP website (free for subscribers). You'll find it in the June 2016 "Shop" section.

Installation, set-up & use

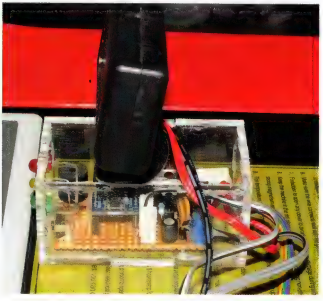
Once the radiator assembly had been built and all the plumbing done, the most difficult remaining task was routing the wiring under and through the internals of the laser-cutter to emerge near the control panel at upper right. We used a variety of methods to string the wires and keep them neat, including P-clamps attached to screws protruding from the bottom of the unit, adhesive wire clips, cable ties, heatshrink tubing and even clamping the wires with the various flip-down panels on the unit itself.

We ran a 5-way ribbon cable from the fans to the control box for 12V fan power and speed monitoring, plus a 3-wire ribbon cable for the water flow sensor and a 2-wire lead for the temperature sensor. The only extra wiring required was the aforementioned 12V power supply wiring from the laser cutter internals to the control box.

To extend the short 3-way cable supplied with the flow sensor, we simply soldered a 3-way ribbon cable onto the end of a standard 3-pin header, plugged this into the locking plug from the sensor (which also has 2.54mm pin

The Cooling System Monitor sits on top of the laser cutter, just behind the control panel. It's connected to temperature and flow-rate sensors that are fitted to the radiator and sounds a piezo transducer if a problem is detected.

Right: a side-on view of the completed unit. The cables run to the water temperature and flow sensors and to the power supply. The temperature sensor display sits on top of the monitor case and is a standard automotive unit (see parts list).



Parts List

Radiator & plumbing

Note: item codes are for AliExpress, although some may no longer be valid

1 360x120mm U-flow copper radiator with G1/4" inlet, outlet and centre tap (item# 1956079016)
3 Sunon KD1212PTB3-6A 12V 1.9W double ball bearing 120mm fans (item# 2022379891)
3 120mm fan vibration-damping silicone gaskets (item# 32224342946)
3 120mm clip-on plastic fan grilles (Rockby Electronics code 39067)
1 automotive temperature sensor with LCD display, mounting bracket and G1/8" threaded sensor (item# 32450099507, "10mm" sensor)
1 G1/4" end cap, to block centre tap port in radiator (item# 32264189117 [pack of two])
1 G1/2" 1-30L/min Hall effect flow sensor (item# 32605214366)
1 G1/2" female-female copper/brass adaptor (item# 32345278486 [#3])
1 G1/4" male-female-female brass tee fitting (item# 1902581471 [pack of three])
1 G1/4" male to G1/8" female brass adaptor (item# 1926696115 [pack of five])
1 G1/4" male to G1/4" female brass elbow adaptor (item# 1922705891)
1 G1/4" male to G1/2" female brass adaptor (item# 1876999872 [pack of two])
1 G1/4" male to 8mm hose barb brass adaptor (item# 1924530597 [pack of two])
1 G1/2" male to 8mm hose barb brass adaptor (item# 1924378817 [pack of two])
1 2m length 8mm ID 12mm OD food grade silicone tubing (item# 32410550179)
8 M4 x 40mm machine screws
4 M4 x 45mm machine screws
12 M4 nuts
6 small L-shaped brackets (from Bunnings)
1 electronics module (see below)
1 "Mini Switcher" step-down module (see February 2012 issue; Jaycar KC5508, Altronics K6340)
1 small piece protoboard
3 3-pin polarised headers
1 3-pin header

Miscellaneous

Teflon tape, various cable ties, P-clamps, adhesive clips and short lengths of heatshrink tubing

Electronics module

1 small protoboard (with copper "donuts")
1 set of laser-cut case pieces
1 small tube acrylic glue
1 200mm length thin double-sided tape
1 5V Pro Micro-clone Arduino module (MOD1; Ali Express item# 32284746884)
1 10kΩ linear 9mm potentiometer (VR1)
1 3-way polarised pin header & plug (CON1)
2 2-way mini terminal blocks (CON2,CON3)
1 5-way right-angle polarised pin header & plug (CON4)
1 mini 12V sealed piezo transducer (PB1) (Jaycar AB3459, Altronics S6105)
1 right-angle tactile pushbutton (S1)
1 1.1A hold, 2.2A trip polyswitch (PTC1) (eg, RXEF110K)
1 100µH 3A powdered-iron core toroidal inductor (L1)
1 2m length rainbow cable
1 2m length light-duty figure-8 wire
2 12-pin female headers (for MOD1)

Semiconductors

1 IRF9540 P-channel Mosfet (Q1)
1 2N7000 N-channel small signal Mosfet (Q2)
1 5mm high-brightness diffused green LED (LED1)
1 5mm high-brightness diffused yellow LED (LED2)
1 5mm high-brightness diffused red LED (LED3)
4 1N4004 1A diodes (D1, D3-D5)
1 1N5819 1A Schottky diode (D2)

Capacitors

2 220µF 16V low-ESR electrolytic

Resistors (0.25W 1% unless specified)

4 1kΩ	3 220Ω
2 470Ω 0.5W 5%	1 22Ω

spacing) and used a heatshrink tubing sleeve to hold the assembly together. Similarly, three polarised headers soldered onto a small piece of phenolic prototyping board were used to connect the 5-way ribbon cable to the three fan power speed-sense cables.

Having completed the wiring, all we had to do was switch the laser cutter on and press S1. Green LED1 lit up. We then unplugged power to the water pump and checked that red LED3 lit instead and that PB1 beeped constantly. Plugging water pump power back in silenced the alarm. Similarly, turning down the fan speed triggers the alarm (and automatically sets the fans to run at maximum speed).

We decided to run the fans near maximum speed, with potentiometer VR1 almost fully clockwise, as the noise is drowned out by other components of the system and this provides the best cooling.

To reduce fan speed, it's necessary to initially do so in stages, pressing switch S1 as you go, to prevent the alarm from triggering and forcing them to maximum speed. Once the nominal fan speed has been reduced, VR1 can then be used to adjust the speed up and down as you would expect, as long as it is not set below the nominal level.

Conclusion

Fitting the new cooling system really transformed the laser cutter. With the original cooling system, we had to wait for around an hour between cutting large panels to let the water cool down and we got inconsistent results, with cuts made later in each run not necessarily going all the way through the material. Now the laser cutter can run continuously all day with barely more than a 10°C rise in water temperature and with perfectly consistent cut depth.

Importantly, we now have peace of mind since we will be immediately alerted to any serious problem which may occur with the laser cooling system and we can check the water temperature at a glance. SC

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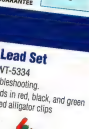

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MEDIUM MPV4 HB-6383 **$99.95**
- Internal: 400(W) x 322(D) x 145(H)mm
- External: 410(W) x 332(D) x 155(H)mm

LARGE MPV7 HB-6385 **$129**
- ...ternal: 480(W) x 355(D) x 180(H)mm
- ...rnal: 515(W) x 365(D) x 190(H)mm

CASE MPV8 HB-6387 **$189**
- ...: 510(W) x 292(D) x 175(H)mm
- ...rnal: 530(W) x 355(D) x 225(H)mm

HB-6389

FROM $24.95

1 YEAR WARRANTY

HB-6387

USB Mini Inspection Camera
WITH 7M FLEXIBLE CABLE QC-3374
Water resistant inspection camera with a massive flexible 7m cable which remains rigid allowing you to probe into all sorts of hard to reach places. Plug it into your laptop and view the camera live, record videos, and take snapshots 10mm camera head outer diameter.
- Hook, magnet and 45° mirror attachments
- 4 white LEDs (brightness adjustable)
- Compatible with Windows XP, Vista, 7, 8

$74.95

See terms & conditions on page 8.

TOOLS AND ACCESSORIES

NERD PERKS 2x POINTS

$4.95

NEW

Multifunction Pocket Tool
TH-1838

Made from stainless steel. Features a can opener, screwdriver, ruler, bottle opener, 4 position spanners, saw blade, directional auxiliary indication and a lanyard hole. Supplied with pouch.

- 68(L) x 45(W) x 2(D)mm

$13.95

Budget 150mm Digital Vernier Calipers TD-2081

Easy to use calibrated digital display with corresponding etched vernier scale.

NERD PERKS 2x POINTS

- 150mm measurement range
- 245mm Overall length (closed)
- Includes 1 x CR2032 battery

ALSO AVAILABLE:

PRECISION DIGITAL VERNIER CALIPERS TD-2082 **$39.95**

$19.95

100W Large Glue Gun TH-1999

Great for repairs to timber, cardboard, paper and many household materials.

- Trigger controlled glue feed
- Mains powered
- Requires 12mm diameter glue sticks (2 supplied)

GLUE STICKS PACK OF 6 TH-1995 **$4.95**

GLUE STICKS PACK OF 45 TH-1996 **$17.95**

ALSO AVAILABLE:

30W MINI GLUE GUN TH-1997 **$12.95**

$22.95

Handy Tools

FOR NETWORK INSTALLERS TH-1740

Cat5 Adjustable Punch-Down Tool

Designed for seating wire into terminal blocks and has an adjustable internal impact mechanism. Supplied with 88 blade. 152mm long.

$19.95

6 Piece Insulated Electronic Screwdriver Set TD-2026

Ergonomic handles with excellent non-slip grips. Fully insulated 1000V rated shafts. Storage case included. Slotted: 2mm, 2.5mm, 3mm. Phillips: #00, #0, #1. TUV and GS approved.

ALSO AVAILABLE:

1,000V 7 PIECE SCREWDRIVER SET TD-2022 **$34.95**

FROM $29.95 SAVE $5

Rotary Tool Kits

Drill, saw, sand, polish, carve or grind.

110 PIECE TD-2451 **WAS $34.95 NOW $29.95 SAVE $5**

210 PIECE WITH FLEXIBLE SHAFT TD-2459 **WAS $54.95 NOW $49.95 SAVE $5**

$39.95

35 Piece Multi-purpose Precision Tool Kit

WITH VINYL CASE TD-2117

A precision screwdriver tool set consisting of 30 bits, two cutters, two pliers and a flexible shaft adaptor for those tricky to reach screws. Ideal for electronic tradesmen and hobbyists.

- 180(L) x 125(W) x 30(D)mm

$54.95

Electric Screw Driver Kit

102 PIECES TD-2491

A powerful high torque electric driver with a massive array of stainless steel bits. Packaged in a tough aluminium carry case.

- 3.6V
- 144(L) x 135(H) x 40(W)mm screwdriver dimensions
- 250(L) x 153(H) x 88(D)mm case dimensions

ONE CRIMP TOOL TO RULE THEM ALL

NERD PERKS OFFER

ADD 3 DIES FOR $40 SAVE $13.85*

*Valid with purchase of TH-2000

Heavy Duty Crimp Tool

WITH QUICK INTERCHANGEABLE DIES TH-2000 **$49.95**

Uses quick interchangeable dies, no screwdriver needed. Features ratchet mechanism for maximum power and quick release.

DIES TO SUIT:

6P6C RJ11/12 TH-2001 **$17.95**

8P8C RJ45 TH-2002 **$17.95**

INSULATED TERMINALS TH-2003 **$17.95**

BNC/TNC RG58/59/62 TH-2004 **$17.95**

F CONNECTORS CATV RG6/59 TH-2005 **$17.95**

NON-INSULATED TERMINALS 26-18AWG TH-2006 **$17.95**

NON-INSULATED TERMINALS 20-10AWG TH-2007 **$17.95**

SMA/FIBRE OPTIC 1.09-6.48MM TH-2008 **$17.95**

SMA/FIBRE OPTIC 1.07-4.52MM TH-2009 **$17.95**

CUTTERS AND CRIMPERS

NERD PERKS 2x POINTS

$12.95

Precision 127MM Angled Side Cutters TH-1897

Precision side cutters ideal for fine PCB work. Made from quality tool steel, with spring loaded soft padded handles.

$69.95

2-in-1 Crimp & Test Tool

TH-1939

An integrated cable stripper and cutter, with detachable cable tester. It can quickly and easily test Ethernet twisted pair cables for wiring continuity, opens, shorts, and mis–wires. Includes PoE tester.

- Suits 10P, 8P, 6P, 4P
- Single and multi–wired cable crimping

DOUBLE POINTS FOR NERD PERKS CARD HOLDERS ON THESE ANTI-STATIC AND MAGNETIC ACCESSORIES

$9.95

NERD PERKS 2x POINTS

Conductive Brush

TH-1775

The handle is made from conductive plastic, and the comb from conductive nylon. Use it to clean anything where static is a problem.

- Features a conductive plastic handle and conductive nylon comb
- 10k - 10m Ohm resistivity
- 178mm long

$13.95

Anti Static Wrist Strap TH-1780

Use when static electricity is a problem when soldering.

- Consists of adjustable velcro wrist strap, coiled lead and banana plug/alligator clip
- Expanded lead length approx. 1.8 m

NERD PERKS 2x POINTS

ALSO AVAILABLE:

3M COILED LEAD TH-1781 **$17.95**

NERD PERKS 2x POINTS

$12.95

8x10 Inch Magnetic Mat TH-1867

This mat is great for keeping nuts and bolts in place when disassembling all kinds of gadgets and phones. Note: The magnetic side of the mat is the "Whiteboard" side which allows you to write references or notes next to the nuts and bolts.

- 254(W) x 203(H)mm

$29.95

Large Rare Earth Magnets

PAIR LM-1652

They are made from NdFeB (Neodymium Iron Boron) providing the highest available magnetic strength material. Suitable for a wide variety of applications. Nickel coating. Sold as a pair.

- NdFeB, N35 Grade
- 19mm Dia x 28.2mm Long

$19.95

Board not included.

Desktop PCB Holder

WITH ADJUSTABLE ANGLE TH-1980

A versatile holder suitable for working with different shaped components, connectors, soldering strips, etc. Also good for field service work.

- Maximum holding size is 200(L) x 140(W)mm
- 300(L) x 165(W) x 125(H)mm

$39.95

Vacuum Bench Vice

WITH 75MM JAW TH-1766

High quality vacuum vice made from diecast aluminium. Consists of a vacuum base, ball joint clamp and a 75mm opening jaw with removable soft rubber jaw covers.

- Working position can be varied through a full 360° axis
- Approximately 160mm tall

NOW $24.95 SAVE $5

LED Headband Magnifier

QM-3511 **WAS $29.95**

This magnifying headset leaves both hands free and can be worn over prescription or safety glasses.

- Adjustable head strap
- Built-in LED work light
- 1.5x, 3x, 8.5x or 10x magnification.
- Requires 2 x AAA batteries

Universal Drill Press Stand TD-2463

Convert your standard power drill or rotary tool into a drill press with this adjustable stand.

Can be adjusted to suit a variety of tools. Features heavy duty cast metal base and frame for excellent stability.

- Drilling depth: Up to 60mm
- 497(H) x 350(W) x 160(D)mm

$39.95

$109

Desk Mount LED Laboratory Magnifier Lamp QM-3546

This is a high quality, all metal frame construction magnifier. Features 90 super bright LEDs. and a quick repositioning metal handle.

- Total extended length 900mm
- Includes generous 2 metre long cord

$179

1kg Digital Bench Scale

QM-7264

Precision 1kg electronic scale with 0.01g resolution accuracy. Weighs in grams, ounces, pounds, grains, carats, troy ounces. Supplied with a wind shield and a built-in bubble level.

- Powered by included mains adapter or 4 x AA batteries (not included)
- 175(W) x 75(H) x 260(D)mm

NERD PERKS CLUB MEMBERS RECEIVE:

10% OFF ALL SOLDER ROLLS & HOBBY PACKS

Duratech Solder

60% Tin / 40% Lead.

1KG ROLLS

0.71MM NS-3002 **$74.95**
1.00MM NS-3015 **$74.95**

200G ROLLS

0.71MM NS-3005 **$15.95**
1.00MM NS-3010 **$15.95**

HOBBYPACK CANNISTERS

0.71MM NS-3008 **$1.95**
1.00MM NS-3013 **$1.95**

NERD PERKS 2x POINTS

FROM $1.95

SOLDERING

Goot Desoldering Tool TH-1856

High quality GOOT brand desoldering tool. Japanese built quality and a large vacuum chamber for strong suction.

- 330mm long

$27.95

$79.95

Goot 80W 240V Soldering Iron

TS-1430

With its high insulation and low current leakage, soldering of precision flat ICs and CMOS is safe. 320° Tip temperature. Exceptional heat recovery. Japanese made.

NOW $149 SAVE $10

Portasol Super Pro Gas Soldering Tool Kit

TS-1328 **WAS $159**

Your companion for any soldering need. Includes:

- Quality storage case.
- Cleaning sponge and tray
- 2.4mm & 4.8mm double flat tip
- Hot air blow, knife tip & deflector

Gas sold separately NM-1020 $5.95.

Lead-Free Solder

99.3% Tin / 0.7% Copper.

200G ROLLS

0.71MM NS-3088 **$24.95**
1.00MM NS-3094 **$24.95**

500G ROLLS

0.71MM NS-3090 **$49.95**
1.00MM NS-3096 **$59.95**

HOBBYPACK CANNISTERS

Contains 15-20G weight

0.71MM NS-3086 **$2.95**
1.00MM NS-3092 **$2.95**

NERD PERKS 2x POINTS

FROM $2.95

AEROSOLS, ADHESIVES & TAPES

175g Aerosol Service Chemical Spray Cans

ELECTRONIC CLEANING SOLVENT NA-1004
CONTACT CLEANER LUBRICANT NA-1012
ELECTRONIC CIRCUIT BOARD CLEANER NA-1008
CIRCUIT BOARD LACQUER NA-1002

NERD PERKS 2x POINTS

$11.50 EA

NA-1004

$14.95

25ml J-B Weld Epoxy

NA-1518

An easy, convenient and inexpensive alternative to welding, soldering and brazing. Two-part epoxy resin when mixed together forms a compound as tough as steel - and with similar properties. Bonds to almost any surface.

NERD PERKS 2x POINTS

NM-2836

Liquid Electrical Tape

FROM $15.95

Seals and protects electrical connections: it won't crack, peel or harden even under extreme conditions.

28G TUBE BLACK NM-2836 **$15.95**
28G TUBE RED NM-2838 **$15.95**
118ML CAN BLACK NM-2832 **$29.95**
118ML CAN RED NM-2834 **$29.95**

GAFFA TAPE ON STEROIDS!

$29.95

Silicone Rescue Tape NA-2829

Permanent air-tight and water-tight seal in emergency situations. Designed for quick plumbing repairs, sealing hoses, coating ends etc. Will repair a broken radiator hose (in most cases).

- 25mm wide x 3.6m roll

See terms & conditions on page 8.

ARDUINO® COMPATIBLE MODULES AND SHIELDS

$9.95

3 Axis Compass Magnetometer Module ARDUINO® COMPATIBLE

XC-4496

This module allows you to take accurate compass bearings, no matter how it is orientated. Easily interfaced via I²C.

- Includes 5V - 3V level shifter.
- 20(L) x 16(H) x 5(H)mm

$9.95

Arduino Compatible Alcohol Sensor Module

ARDUINO® COMPATIBLE XC-4540

The analogue output can be used to monitor changes in alcohol concentration, while a digital output is triggered when the concentration exceeds a pre-set threshold.

- 5VDC
- Adjustable sensitivity
- 50(L) x 20(W) x 13(H)mm

$10.95

Sensor Expansion Shield

ARDUINO® COMPATIBLE XC-4452

Connecting 3-pin analog sensors in a snap. Also includes 4-pin communications port that can be set for either UART or I²C. Plug and Play connection for servos, sensors, switches and more!

- 68(W) x 57(D) x18(H)mm

NEW

$44.95

MIDI Shield

ARDUINO® COMPATIBLE XC-4545

Add musical instruments by giving your Arduino project a powerful MIDI communication protocol. The MIDI protocol shares many similarities with standard asynchronous serial interfaces, so you can use the UART pins of your microcontroller to send and receive MIDI's event messages. The MIDI Breakout provides both MIDI-IN and MIDI-OUT connections, as well as a MIDI-THRU port.

$5.95

PIR Motion Detector Module

ARDUINO® COMPATIBLE XC-4444

A pyroelectric infrared PIR motion sensor is a handy addition to any Arduino® project. Wide operating range and delay times changeable. A must for any security application.

- 32(L) x 24(W) x 25(H)mm

$7.95

Line Trace Sensor Module

ARDUINO® COMPATIBLE XC-4474

This module measures the reflectivity of a surface with an infrared emitter/detector pair.

- VCC/OUT/GND pin connector
- 2.5~12V power supply
- 18-20mA at 5V working current

$9.95

Obstacle Avoidance Module

ARDUINO® COMPATIBLE XC-4524

An inexpensive solution for an IR obstacle avoidance sensor, easy interface with Arduino® & compatible boards. Adjustable frequency and intensity. 4 pin header.

- 42(L) x 27(W) x 18(H)mm

$129

Deluxe Modules Package

XC-4288

Get more savings by purchasing this 37 modules-in-1 pack. Includes commonly used sensors and modules for duinotech and Arduino®: joystick, magnetic, temperature, IR, LED and more.

NEW

$29.95

Screw Shield

ARDUINO® COMPATIBLE XC-4553

The Screw Shield extends all pins of the Arduino out to 3.5mm pitch screw terminals. The screw terminal blocks allow sturdy, secure and dependable prototyping without the need for soldering.

NEW

$34.95

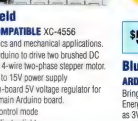
RS485 Shield

ARDUINO® COMPATIBLE XC-4554

Add a RS485 port to Arduino using this handy shield.

- Comes fully assembled with shield stacking headers

NEW



$39.95

Motor Shield

ARDUINO® COMPATIBLE XC-4556

Perfect for robotics and mechanical applications.

- Enables the Arduino to drive two brushed DC motors or one 4-wire two-phase stepper motor.
- Requires a 6V to 15V power supply
- Includes an on-board 5V voltage regulator for powering the main Arduino board.
- PWM speed control mode
- 4 Direction indicator lights
- Extra large heat sink
- Supports up to 14 servos

NEW

$59.95

Bluetooth 4.0 Shield

ARDUINO® COMPATIBLE XC-4549

Brings the latest Bluetooth 4.0 BLE (Bluetooth Low Energy) to Arduino. A single button battery (such as 3V 220mAh CR2032) on a Bluetooth 4.0 single mode chip could work for months or years. Startup time is only a few milliseconds compared to about 4 seconds on the Bluetooth 2.1.

SAVE 15% ON THESE FREETRONICS MODULES & SHIELDS

freetronics

NOW $8.45
SAVE $1.50

Shift Register Expansion Module

ARDUINO® COMPATIBLE

XC-4240 **WAS $9.95**

Drive up to 8 devices using just 3 pins on your microcontroller. Daisy-chain them together to drive 16 channels or even more without sacrificing precious output pins. 2 to 6V operation.

- Blue power LED
- 23(W) x 16(H) x 4(D)mm

freetronics

NOW $19.50
SAVE $3.45

Axis Accelerometer Module

ARDUINO® COMPATIBLE

XC-4226 **WAS $22.95**

Operates in either +/-1.5g or +/-6g ranges, giving your project the ability to tell which way is up.

- Independent X, Y, and Z axis outputs
- Can run from either 5V or 3.3V
- Zero-G free-fall detection
- 23(L) x 15(W)mm

freetronics

NOW $25.95
SAVE $4.50

Humidity & Temperature Sensor Module

ARDUINO® COMPATIBLE

XC-4246 **WAS $29.95**

Measure temperature and relative humidity using a simple interface that requires just three wires to the sensor: GND, power, and data. 3 to 5V operation.

- -4°C to +126°C temp. range, +/-0.5°C accuracy
- 0.5Hz sample rate (one sample every 2 seconds)
- 31(W) x 23(H) x 4(D)mm

freetronics

NOW $29.70
SAVE $5.25

RFID Door Lock Shield

ARDUINO® COMPATIBLE

XC-4215 **WAS $34.95**

Control a door lock using an electric strike plate and a RFID module. Example source code online.

- Output to control 12V electric door strike
- Supported readers include ID12, ID20, RDM630, RDM880, and HF MultiTag
- Onboard voltage regulator to power Arduino®
- 49(W) x 54(D) x 27(H)mm

ARDUINO® COMPATIBLE ACCESSORIES AND DIY ESSENTIALS

ARDUINO® PROJECT FOR NERD PERKS CARD HOLDERS

SEE STEP-BY-STEP INSTRUCTIONS ON www.jaycar.com.au/rct

Build Your Own Resistor And Capacitor Tester

If like us you're always having to sort through your junk drawer and have trouble with your colour codes, here's a handy project for you. This tester will try to work out whether you are connected to a resistor or a capacitor and then show you the relevant value. If it's a resistor, it'll also suggest the nearest resistor from the Jaycar ¼W range. No more sorting through your draws blindly!

VALUED OVER $73

BUNDLE DEAL INCLUDES:

UNO BOARD XC-4410 **$29.95**

PROTOTYPING SHIELD XC-4482 **$15.95**

LCD AND PUSHBUTTON SHIELD XC-4454 **$19.95**

150R RESISTOR (¼W) RR-0552 **$0.55**

1K2 RESISTOR (¼W) RR-0574 **$0.55**

10K RESISTOR (¼W) RR-0596 **$0.55**

PLUG-PLUG JUMPER LEADS WC-6024 **$5.95**

NERD PERKS CLUB

BUY ALL FOR $59

SAVE OVER $14

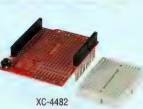
Completed project.

DIY

Resistors

WC-6024

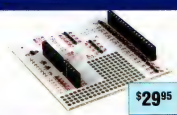
XC-4454



XC-4482

XC-4410

MORE ARDUINO® ESSENTIALS



$29.95

Voltage Converter Module

FOR XC4350/52 PCDUINO XC-4362

This shield safely marries 5V Arduino shields with the 3.3V pcDuino. This shield sits between the pcDuino and the 5V shield and provides bi-directional voltage translation.

- 70(L) x 50(W) x 4(D)mm

$34.95

Light Duty Hook-Up Wire Pack

8 COLOURS WH-3009

Quality tinned hook-up wire on plastic spools. 8 rolls included, each roll a different colour.

- 25m on each roll

Assorted LED Pack

$34.95

100 PIECE ZD-1694

This assorted pack contains 3mm and 5mm LEDs of mixed colours. Even includes FREE 10 x 5mm mounting hardware.

pcDuino V3.0

$149

WITH WI-FI XC-4350

pcDuino V3.0 is a high performance, cost effective mini PC platform that runs on Ubuntu or Android ICS. With onboard HDMI, USB, SATA, LVDS and Wi-Fi you can use it in robotics, home theatre, electronic control and other various applications.

- 121(L) x 65(W) x 15(H)mm

MUST HAVE TOOLS FOR YOUR ARDUINO® PROJECTS

New Enthusiast Starter Bundle

VALUED OVER $88

The ideal starter package for young electronics enthusiasts or the home handyman, especially so if an Arduino® fan.

25W SOLDERING IRON SET TS-1652 **$39.95**

BENCHTOP WORK MAT HM-8100 **$12.95**

ROSIN SOLDERING FLUX NS-3070 **$15.95**

PCB HOLDER WITH MAGNIFYING GLASS & CLIPS TH-1987 **$19.95**

BUNDLE OFFER

BUY ALL FOR $69

SAVE OVER $19

TH-1987

TS-1652

HM-8100

NS-3070

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!

*Conditions apply. See website for T&Cs

REGISTER ONLINE TODAY BY VISITING: www.jaycar.com.au/nerdperks

CLEARANCE SAVE UP TO 60%

10 Piece Reinforced Plastic Tool Set

TD-2116 WAS **WAS $4.95**

A must have for all hobby enthusiasts, this tool set prevents any damage to the fasteners (screws & nuts) on your projects. With its insulating properties, you will also be safe from electrical current and dangerous chemicals.

NOW $2.95 SAVE 40%

30 Amp SPDT Relay - Standard Size

SY-4072 **WAS $7.45**

PCB version of standard 30A horn type relay. Whilst designed for auto horns, this relay is ideal for any high current application i.e. burglar alarms, ignition cutout, transmitters, car spotlights etc.

- Contact current (max) 40A
- Contact voltage (nom) 12V
- PC pin tab termination

NOW $2.95 SAVE 60%

Plastic Molded Enclosure

DARK GREY

HB-6036 **WAS $18.95**

Includes removable front and rear panels. Designed to IP54 of IEC 529 and NEMA4 with respect to moisture and dust proof sealing, flame retardant to UL94-VO.

- 190(W) x 100(D) x 40(H)mm

NOW $9.95 SAVE 47%

Drill Assistant with User Leveller

TD-2151 **WAS $19.95**

Drill holes in walls easily, on the level and with no mess. Built-in laser and level. Has vacuum suction, drill guide, and dust catcher.

- Requires 2 x AA batteries
- 238(L) x 100(W) x 48(H)mm

NOW $15.95 SAVE 20%

300mm (12") Copper Cable Shears

TH-1900 **WAS $24.95**

Super heavy duty cutters feature a precision cutting head forged from carbon steel attached to drop forged steel handles for extra leverage. Designed to cut copper cable up to 35mm² you can slice through just about any cable up to 2 gauge. The handles are coated to prevent corrosion and have rubber grips for operator comfort.

- 310(L) x 90(W) x 40(H)mm

NOW $14.95 SAVE $10

Smartphone Sensor Plug-in Modules

WITH APP WERE $34.95

Turn your Smartphone into a pocket environment meter. Choose between four plug-in sensors. By using a free downloadable APP for your iOS® and Android® device, you can see real time measurements or trigger an alarm when a pre determined measurement is reached.

PLUG-IN GEIGER MODULE QM-1676

PLUG-IN UV MODULE QM-1677

PLUG-IN ELECTROMAGNETIC SENSOR QM-1678

PLUG-IN TEMPERATURE AND HUMIDITY SENSOR QM-1679

QM-1676

NOW $29.95 SAVE $5

12 Compartment Portable Storage Cabinet HB-6301 **WAS $44.95**

The system features a "double lock" closure on each storage box.

- 2 x large 295(W) x 65(D) x 65(H)mm (all are 65(D) x 55(H)mm)
- 4 medium 145(W)
- 6 small measuring 95(W)mm
- Attachè-case: 300(W) x 310(H) x 145(D)mm

NOW $34.95 SAVE $10

Professional Digital Light Meter

WITH COVER & CASE QM-1584 **WAS $169**

Uses photopic spectral sensitivity to measure light level in terms of Foot Candles(FC) or LUX over a wide range. Includes a long-life silicon photo diode sensor, min & max measurements, easy to read back-lit display and data hold.

WARRANTY

NOW $129 SAVE $40

TERMS AND CONDITIONS: REWARDS / HERO PERKS CARD HOLDERS FREE GIFT, 4% SAVING BEADS, DOUBLE POINTS & MEMBERS OFFERS applies **ACTIVE** Jaycar Rewards / Hero Perks Card membership (proof of purchase) is required. Refer to website for Rewards/ Hero Perks Card T&Cs. **ON PAGE 1:** Hero Perk Card holders receive a free 2000 1mm Rail Solder (NS-9010) with the purchase of TS1584. Special price for HR-6816. **ON PAGE 2:** Special price for 6 amazing deals. Can (500 ml) and CNA Spray Paints available with the purchase of HB-6061, SF-2000, SF-2270 and SF-2271. **ON PAGE 3:** Hard Drive Card holders receive a Side Pro Leather Tool Utility Belt (HB-6370) with the purchase of QM-1561, QM-1563, NS-3016, NS-3066, NS-3068, NS-3069, NS-3070, NS-3073, NS-3088, NS-3094, NS-3095, NS-3096, NS-3098 and NS-3099. Double points when you purchase TH-1858, TH-2095, TH-1867, TH-1725, TH-1753, TH-1867 and LM-1652. Hard Perks offer for additional discounts with TH-2000 applies to any items from TH-2000/020/030/050/070/080/090 for $40 saving $13.95. **ON PAGE 5:** Hard perk members receive free 200 x 1mm Solder (NS-9005) with the purchase of TS-1584. Double points with the purchase of NA-1004, NA-1012, NA-1008, NA-1004, NA-1016, NA-3002, NS-3016, NS-3066, NS-3068, NS-3069, NS-3070, NS-3073, NS-3088, NS-3094, NS-3095, NS-3096, NS-3098, NS-3099 and NS-3092. **ON PAGE 6:** Special price for the following items: XC-6249, XC-6228, XC-6248 and XC-6115. **ON PAGE 7:** Hard Perk Cardholders will receive XC-4410, XC-4402, XC-4454, RK-0650, RK-0574, RK-0596 and WC-0254 for $59 saving $14. New Enthusiasts Starter Bundle deal applies to TS-1852, MM-4100, MS-3070 and TS-1987 for the price of $89 saving $40. **DOUBLE POINTS ACCRUED DURING THE PROMOTION PERIOD WILL BE ALLOCATED TO THE HERO PERKS CARD AFTER THE END OF THE PROMOTION. DOUBLE POINTS ACCRUED DURING THE PROMOTION PERIOD** will be allocated to the Hero Perks card after the end of the month.

Australian Capital Territory

Belconnen	Ph (02) 6253 5700
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SERVICEMAN'S LOG

Putting the wind up an anemometer

Dave Thompson*

When the wind blows but the anemometer doesn't go, it should be a breeze to fix. Actually, Dad's entire weather station was playing up but first, I had to figure out why the batteries in his transistor radio were quickly going flat.

Items Covered This Month

- Fixing a weather station
- Electric plunge furnace repair
- Kenwood TS-450S transceiver
- Beyonwiz DP-P2 HD PVR

I got a call from Dad the other day, asking if I could help him out with a couple of jobs that he can no longer do. It's tough seeing time taking its inevitable toll and watching my once-capable father growing old just doesn't seem fair somehow.

Once upon a time, he could repair anything and I'll never forget the story one of his friends from his younger days told me. Apparently, they'd taken their motorbikes on an up-country run and the friend's bike had spluttered to a stop out in the middle of nowhere. No problem for Dad; he took out his tool kit and stripped down the bike's engine by the roadside and while his mate couldn't recall exactly what had been wrong with it, it ran well enough after it had been re-assembled to get them home.

~COULD THE WORKSHOP ELVES BE COMING OUT & PARTYING ALL NIGHT?

There were other times too, like when we got stranded out in the middle of the ocean in a boat because the "V" drive failed. On that occasion, Dad jury-rigged something up so we could limp back to port. It seemed that no matter what pickle we got into, Dad could fix it. I loved that feeling of security and it was only natural I'd become a serviceman; it's in my blood.

Over the past few years, Dad has been breaking down his workshop and it's now strangely empty. The various machines and tools have gone to either my brother or to myself but I doubt they'll ever be used as they were in Dad's workshop.

He still has the basics though; a soldering station and other smaller tools and it was these I used recently to repair his old Panasonic workshop radio. This particular transistorised receiver has been in his workshop longer than I can remember and with its leather case and strap, it's the epitome of the late 1960s to early 1970s style of portable radio.

I well remember working in his workshop after school, listening to the latest music (and the rubbish the DJs always seemed to come out with) on this radio, so it really was part of the furniture. I doubt that anything made today would last anything near as long as this one but now it had a problem.

Flat batteries

A couple of months ago, Dad finally got around to putting some batteries in it after it had been sitting silent on a shelf for some years. It initially appeared to work OK but when he tried it the following day, the batteries had gone flat overnight, even though it had been switched off. Thinking he might have chosen some half-flat batteries from the pile in his battery drawer, he replaced them with some known good cells and the same thing happened; they were dead flat the following morning.

Obviously, something was draining the batteries but what? Could the workshop elves be coming out and partying all night? It was up to me to find out!

Years ago, in an effort to avoid going broke due to constantly buying batteries to feed this radio, Dad had installed a power socket so he could run the radio from a small plugpack supply instead. This simply involved breaking the positive line from the battery holder to the circuit board and wiring the socket so that when the plugpack supply was plugged in, the battery was disconnected. Conversely, when the plug was removed, it would run on batteries once again.

Basically, the socket had to be wired this way because the batteries weren't rechargeable types and wouldn't take kindly to being connected across an external power supply!

To be honest, I was half-expecting to open it up and find everything covered in leaked battery gunk. It's so easy to leave batteries sitting in a device and forget all about it, only to come back years later and find it in a sorry (and usually non-working) state. I've done it myself, leaving many very cool and probably now highly-collectible toys and other 60s-era gadgets ruined.

The goo that leaks out of old, dead batteries can be highly corrosive and it tends to attack everything it touches. Over the years, I've often had to tell customers who have left batteries

in devices that those items were now fit only for the rubbish bin. It's a real shame, because it's a totally avoidable waste of good electronic gear.

Anyway, when I got to the radio, I discovered that Dad and my sister had already had a go at it. Impatient, like many good servicemen, Dad had "sis" take the covers off and, acting as his eyes, have a look to see if they could determine what was going on. My sister isn't really into electronics, so it isn't surprising that she and Dad couldn't find anything wrong.

When it was shown to me, I was pleasantly surprised to find there were no leaked batteries; just a wire adrift from the old power socket. Dad mentioned it'd come off when they were poking around in there but that I should be able to see where it came from and take that into account when trying to find out what was going on.

I removed the already-loosened case and had a good look around inside it. I could see the power socket that Dad had put in all those years ago and it was now looking very old and corroded. It also looked to be a bit mangled, as if something other than a plug had been forced into it at some stage.

On closer inspection, the spring-loaded contact that broke the battery circuit when the power plug was inserted appeared to have been twisted around and appeared to be shorting out across the other contacts. My guess was that it was this that was draining the batteries.

Dad wasn't interested in keeping the power socket there so I just fired up his soldering iron, de-soldered all the wires that were left on the socket and reinstated the original connections directly from the battery holder to the PCB. However, before I connected the positive lead, I put my multimeter in series with the wiring and after setting it to measure current, turned the radio on. It drew around 15mA at medium volume, which seemed reasonable to me and certainly wouldn't drain the three C-sized batteries overnight.

Finally, I reconnected everything, replaced the back, switched the set on and marvelled at how much better this radio sounded than anything else I'd heard in a long time. They really don't make them like they used to!

Weather station

With the radio now working, my next job involved taking a look Dad's weather station. My parents have had this station for years; it consists of a bunch of stuff sitting at the top of a 3-metre pole rising from a deck at the front of the house and an LCD screen in a frame hanging on a wall in the lounge room. The two sections connect wirelessly, the sensors on the top of the pole sending the data to the base unit which displays all the relevant information, including indoor/outdoor temperature, humidity, air pressure, wind speed and direction and rainfall.

As well as showing all this weather information, the touch-screen base unit also shows the date and time. At least, it should display all that stuff but there were a few issues with Dad's unit. For a start, the wind speed indicator showed nothing, which wasn't surprising as the anemometer had lost most of one of the three little cups it uses to catch the wind and measure its speed. This meant that the device didn't turn much at all, leaving a flat-line display on the base unit.

Several other functions were also displaying either a "0" or flat-lining, indicating that the batteries in the remote sensors were probably dead (or dying).

Dad had reminded me to bring over some tools to drop the pole and so armed with a Phillips screwdriver I first removed the screws holding the supporting brackets. After carefully removing the last one, I then gently lowered the pole down before laying it on the deck in order to get to the sensor units.

Before I could do anything though, I had to remove the mass of cobwebs and dead insects that seemed to fill every nook and cranny of the array. I had to be a careful though, as the plastic was almost powdery in places due to UV and weather exposure.

There was nothing for it but to remove the anemometer entirely so that I could take it home and fit another cup to it. To do this, I had to undo three small machine screws and carefully release the wire from the clips holding it in place along the plastic shaft. A few of these clips literally shattered as I put pressure on them, such was the state of the framework.

With that part clear, I needed to remove some of the plastic covers in order to unplug the anemometer unit. The device utilises RJ11 plugs and sockets (the same as US-style phone connectors) and these are removed by pushing a small plastic tab in on one side in order to release the plug from the socket.

Once again, spider webs and the remains of their insect meals were everywhere underneath the covers, which probably wouldn't be helping

Servicing Stories Wanted

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the accuracy of some of the sensors! Indeed, some webs were so thick I literally had to push them off with the screwdriver and then pull them away with my fingers.

Finally, I uncovered the battery compartment and removed the two old AA-size cells. One had started leaking a little, so they had obviously done their dash, with Dad complaining tongue-in-cheek that batteries don't last like they used to, as these had only been in service six or seven years! I gave the terminals a quick rub over to make sure there was nothing on them, then installed two new cells and replaced the battery cover.

Leaving the anemometer to one side, I then hoisted the pole with one hand and attached the supporting brackets with the other. We then made our way inside and tried the base unit but, rather disappointingly, it still showed nothing. Suspecting that the problem may lie in the base unit itself, I took it down and replaced the batteries with fresh ones, even though Dad had told me that he'd recently changed them because he thought that might be why it hadn't been displaying the data from the sensors.

When I put the last new cell in and replaced the cover, most of the readings were now being displayed. The wind speed wasn't showing up because I had removed the anemometer but the outside temperature wasn't showing up either, so there was still a fault on the pole.

Once again, I went through the process of dropping the pole and removing all the covers. I was thinking that perhaps the anemometer had to be plugged in for the outside temperature to be shown; that maybe they were on the same circuit, or something like that.

~TO SAVE MY AGEING SERVICEMAN'S LEGS FROM MAKING REPEATED TRIPS TO & FROM THE HOUSE

I plugged the wind speed sensor back in and checked the base unit, which I'd cleverly taken with me to save my ageing serviceman's legs from making repeated trips into and out of the house. Of course, plugging the anemometer back in had no effect on the temperature reading (but you probably already knew that) so I had to look elsewhere.

I stripped the other sensors off again and cleaned all the phone-style sockets, then made sure that the various plugs had perfectly clean contacts before putting everything back together again. This time, after "rebooting" the base unit again (by removing and replacing the cells), all the figures showed up and appeared to be accurate, if the old mercury thermometer mounted outside the house was anything to go by. And so the pole went back up again and the base unit was placed back in its niche on the wall.

That just left the wind speed sensor which I then took home with me. It's really just a brush-motor fitted with three small hollow cups mounted at 120° intervals to catch the wind. Depending on the wind speed, the motor's armature generates a small voltage at the output of the field and this is fed to the wireless sender via a single RJ11 connector.

As mentioned, a large section of one of the cups was missing. I'm not sure how it got knocked off but going by the state of the remaining plastic, heavy rain drops could have done the job!

I thought that half a ping-pong ball might make a good replacement so I fished one out of my bit'n'pieces

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Electric Plunge Furnace Repair

A simple but puzzling fault can completely cripple a large piece of industrial equipment. D. T. of Prospect, SA recently got a large metal furnace going again with replacement parts costing less than $5.00 . . .

A friend's brother recently rang me, enquiring if I had any experience with repairing electric smelting furnaces. Apparently, they were in big trouble as no-one had been able to repair their plunge furnace and they desperately needed to get it going again.

This was definitely not in my normal line of work but I'm always up for this kind of challenge. And so I offered to have a look at it and see if I could help.

It was just like a massive machine monster from a horror movie! It consisted of a large crucible some two metres across which could be tipped to pour molten metal into moulds. I was fascinated to see recipe books which listed the exact mix of different scrap metals required (in carefully weighed portions) in order to produce just the type of metal needed for each project. Included in their metal stockpile were copper pipes, scrap stainless steel and even steel parts from an old bike!

Three 150mm x 3m-long rods made of what looked like carbon were suspended at the ends of chains above the pot. These were in turn connected to three motors hanging from the roof. The control panel consisted of three very large current meters with full-scale readings of over 250A, press buttons to raise and lower the rods and a power on/off switch with an auto position.

It was all quite daunting, even while sitting there turned off and not moving.

When the power was turned on, it turned into a loud fire-breathing monster. The rods were lowered into the mix and as soon as a rod touched the mix it started arcing through the load to the crucible, causing fireworks and lots of noise. The problem quickly became apparent. As soon as an arc was struck, two of the three rods would correctly retreat and then return again to maintain the arc and thus continue heating the metal.

By contrast, the third carbon rod just continued to push on into the load. At the same time, its associated current meter was pinning its needle at full scale until the whole system tripped out.

I began my troubleshooting procedure by analysing how it was all meant to work. The plunge motors on the carbon rods were 3-phase 1hp (750W) types driven by three 3-phase contactors, one to activate the motor and the others to swap two of the phases over to reverse the motor direction and therefore the direction of the carbon rod attached to it.

Each rod and motor was supplied from the 3-phase supply via a large transformer which I estimated to be rated at around 350kVA. In addition, each carbon rod had a current sensor coil fitted to its supply to monitor the current through that rod. This obviously supplied a feedback circuit to activate the reversing function of each motor to maintain the arc from that particular carbon rod.

I found that I could raise or lower the rods manually which indicated that the motors and any associated mechanical gear were OK. That meant that the fault had to be in the electronic control circuitry.

This control circuitry was spread across three identical, sparsely-populated PCBs. These PCBs were so old that they were made from the now obsolete phenolic material. Unfortunately, spare PCBs were no longer available (and hadn't been for years), while obtaining a circuit diagram was also out of the question.

In order to prove that the faulty rod's corresponding control PCB was the problem, I decided to swap it with one of the other PCBs. They were reasonably easy to unplug and remove, so I carefully labelled all the wires and swapped them over. The problem then moved to the other rod, so the fault was definitely on the control board.

drawer and compared it with one of the remaining cups for size. Amazingly, it was exactly the same!

The problem now was cutting the ball in half. I don't know if you've ever tried it, but cutting a ping-pong ball in half is really, really difficult!

I initially tried using my old Dremel Moto-Tool scroll saw but gave up after nearly taking one of my fingers off. I did manage to cut about half-way through the ball but in the interests of keeping my fingers intact, did the rest with a new blade in my scalpel.

Even then it was as rough as guts but at least the ping-pong ball was now in two bits. I cleaned up one half down to the seam and then did the same with the other half, which was actually a little smaller than the first one. I then smeared epoxy resin glue over the inside of the smaller half and glued it to the larger half, making sure it lined up neatly.

Once hardened, this made the ball very sturdy, and I made good use of that to rub the edge down on a piece of 400-grit wet-and-dry sandpaper. After sanding, it looked perfectly flat and I then used the same resin to glue the cup onto the remains of the previous cup. It was impossible to tape it into place while the glue set so I just sat and held it for five minutes until the glue hardened enough for me to sit it on the bench to fully cure.

The finished job looked great and the overall balance of the complete assembly is good enough for this purpose. All I have to do now is put it back up the pole and that's job done!

Kenwood TS-450S transceiver

K. G., of One Tree Hill, SA recently had a Kenwood HF amateur-band transceiver fall into his lap. The only catch was that he had to get it working before he could use it. Here's how he went about it . . .

I was recently given an amateur radio transceiver with the message that if I could get it working and make use of it, it was mine. It did not transmit and the receiver was a little "deaf", resulting in very little audio output.

The model concerned is a Kenwood TS-450S which covers the HF amateur bands from 1.8-30MHz and is rated at 100W PEP on transmit. In good working order, this model is still quite a capable transceiver, even though it is now 15-20 years old. As a result, I thought it was worth spending some time on it to see if I could fix its faults.

An age of 15-20 years may seem to be quite old for electronic equipment, given that so much gear is discarded after just a few years. Some of it is now binned in less than five years even if it still working, the reason being that it has been superseded by the latest whiz-bang gizmo. However, amateur radio equipment generally has a much greater life-span than the average piece of consumer electronics.

I took both the faulty unit and a good board back to my workshop and had a closer look at the circuit. It proved to be a very basic feedback arrangement with an output much like that used to control the servo in a radio-controlled toy. I've fixed hundreds of these but the scale was different for this job.

One advantage of being in the electronics game since the days of valve black and white TV is that you accumulate a lot of parts. The faulty board required a couple of very early transistors on the outputs to be replaced, since they had become leaky. As it turned out, I had the exact devices in stock, as they were used in some of the first solid-state portable TV sets.

The two new transistors were duly fitted and I then replaced a couple of electrolytic capacitors which had high ESR readings. I then returned to the monster and refitted the two boards.

I had everything crossed when the Auto button was pushed but it all worked perfectly, with the three amp meters settling down to about half-scale and remaining surprisingly stable. What's more, the mix was reduced to liquid metal surprisingly quickly.

This was definitely a diversion from my normal work but was very rewarding and interesting. I found out later that if the repair hadn't worked, a replacement furnace would have had to have been purchased and shipped from South Africa at massive expense.

With the radio set up on my testbench, I applied a 10µV signal in the 7MHz amateur band to the antenna terminals and tuned it in. Despite this strong input signal, the signal strength meter showed only quite a low reading and the audio level from the speaker was anything but strong. That said, the signal was there and was on the expected frequency. So the various local oscillators in the set were on the correct frequencies.

Next, I connected the radio to a 50-ohm dummy load with an RF power meter in the line. Pressing the push-to-talk lever on the microphone and whistling into the mike should have produced an output power of 50W or more but in this case, no output at all was shown on my power meter or on the radio's internal meter.

Removing the top cover revealed a large empty space where the optional automatic antenna tuner would go. There were several shielded boxes with other parts of the transceiver in them, including (most likely) the transmitter's 100W power amplifier. I concluded that the low-level parts in the transmitter chain were underneath.

Although it was possible that the fault lay in the power amplifier, I figured that the best place to start was early in the transmit signal path. Fortunately, there was a comprehensive user manual with the radio and this included the circuit diagrams. These showed that there were separate RF and IF units in the set and these were easily identified once the bottom cover had been removed.

I expected that the audio signal from the microphone would go to the IF unit first, where it is converted to 455kHz. However, when I attempted to transmit, I couldn't detect any 455kHz signal at the output of the IF unit which was clearly labelled on the circuit as "TXIF" on pin 4 of connector W1. However, there was obviously audio coming from the microphone and there was also audio on the output pin of the microphone amplifier IC (IC15, pin 7).

From there, the signal path went to a mic gain control on the front panel and then through a further amplifier to balanced modulator stage IC8. Attempts to transmit resulted in a 455kHz signal at IC8's output, so everything was OK up to there.

Following the modulator is a set of three ceramic filters with different bandwidths, each selected according to the mode of transmission. For example, the 2.4kHz filter would normally be selected for SSB mode. The selection is done by diode switches and one of the switched DC voltages which controls the diodes is called "TXB" which I measured at a shade under 8V at the input to the IF unit on pin 4 of CN1.

I then looked for the TXB voltage on diodes D11 & D12 but the swing from receive to transmit was nowhere near what I had expected. Next, I looked for the TXB voltage on pin 4 of CN5 but it was way below the 8V measured previously on CN1, even though the two connector pins are supposed to be directly connected together. Now we were getting somewhere.

Measuring the resistance between the two connector pins resulted in a reading in the kilohms region. It was time to remove the IF PCB completely for a close examination and that simply involved undoing five or six screws and unplugging all the connectors.

~K.G. RECENTLY HAD A KENWOOD AMATEUR BAND TRANSCEIVER FALL INTO HIS LAP

Once it was out, I put my multimeter probes on the two connector pins for another check and got the same high reading as before. As an aside, I had recently bought a pair of multimeter probes with needle-sharp gold-plated points. They're just the shot for probing small pads and tracks on PCBs and for poking through tarnished leads and solder to get a good connection.

I followed the track from one connector pin to the other and soon found the discontinuity at a small via. I then noticed some black "gunk" on the board which I realised had come from a nearby large electrolytic capacitor. On checking the circuit again, I discovered that this capacitor coupled signal from the audio power amplifier to the loudspeaker.

I checked this capacitor using my trusty ESR meter and found that the ESR was about 80Ω when it should have been just a small fraction of an ohm. No wonder the audio output level was low on receive.

I replaced the faulty capacitor with a new one and cleaned off as much of the gunk as I could with isopropyl alcohol (IPA). It was then necessary to link the two connector pins with a thin wire to restore continuity. With the PCB back in place in the chassis and all connectors replaced, I then tried the transmitter again and was delighted to find that it now worked. After making a few adjustments, I found that I could measure 120W peak at the output.

Beyonwiz HD PVR Repair

Regular contributor B. P. of Dundathu, Qld likes to rescue and repair non-working PVRs that are advertised on eBay. He bought this one for a song and repaired it using parts on hand . . .

I recently noticed a Beyonwiz DP-P2 HD PVR listed on eBay as not working or for parts. The auction had a few days to run, with several bids already, so I kept an eye on it. As the auction neared the end, I placed a bid, which I considered a fair price for a non-working unit. I've repaired a few Beyonwiz PVRs in the past, so I thought I would take a chance on this one as it was a top model in the Beyonwiz range at the time.

I won the auction and the unit arrived in the mail a few days later. To initially test it, I plugged it into the power and fired it up and sure enough, it stopped with "Error 0000" indicated on the display. I then unplugged it and took the lid off. I hadn't heard the 500GB HDD running when I'd first turned it on, so I unplugged the drive cables, reconnected them and fired the unit up again.

It still came up showing "Error 0000" but I could now hear the HDD running. However, it was very quiet, which explained why I couldn't hear it with the lid on.

I then noticed some muck on one of the larger electrolytic capacitors on the power supply board. A closer look indicated that the capacitor had "erupted" and I then noticed that an identical one nearby was slightly bulging at the top.

I whipped out my soldering iron and allowed it to heat up while I removed the power supply board. The two faulty capacitors were both 3300µF 10V types and these were quickly replaced and the power supply board refitted.

I fired the unit up again and the "Error 0000" message had now cleared. In its place was a TV channel indicator on the front panel, so I connected the unit via an AV cable to a small TV set but I couldn't get a picture, despite pressing the TV-OUT button on the remote to change the video output several times.

I didn't have a spare monitor or portable TV with an HDMI input, so I took the unit into my lounge room and hooked it up to our main TV set. I then got a picture and after connecting the antenna, I was able to tune in all the local channels. A quick flick through all the channels indicated that everything was working well, at least as far as TV reception was concerned.

Next, I checked the recordings on the HDD and found that the oldest recording took place 24/8/11, while the most recent one was on 10/11/12. This indicated that the unit had been used for over a year but had not been used to make any recordings for the past three years. So was the unit able to record properly?

It was time to find out. I set it up to record a program for that evening and all worked correctly. So the power supply had apparently failed in its first year of use.

In view of that, it's likely that the unit had been used in a poorly ventilated area (possibly enclosed in a cabinet), which caused the power supply to run hot and the capacitors to fail. All the other capacitors were still good but the two that had failed looked like a cheaper brand than the others, so they were probably doomed to fail anyway.

I used two recycled Nichicon capacitors to replace the two faulty ones, so the unit should now have a new lease on life. It will eventually be used in our family room but I will need to find a monitor or TV that has an HDMI input, because it may not work on AV on our current TV, although I can test that later. In fact, it could well be the AV input on our small TV that isn't working and I'll check that when I get time.

And so another piece of useful (and still reasonably modern) piece of equipment was saved from the scrap heap. The best part was that it cost nothing to repair it, since I used recycled parts.

Things weren't quite so rosy on receive though. Certainly, the audio output had improved and the sensitivity was better but it still wasn't up to scratch. The receiver's internal noise could be heard and in addition, there was a faint but noticeable crackling in the audio with no input to the radio.

Unplugging the RXIF input to the IF unit at connector W1 gave a drop in the noise but the crackling remained. An IF gain trimpot is positioned halfway along the IF amplifier chain and turning this right down reduced the noise and crackling to zero. That meant that the problem lay somewhere between the input to the IF board and the trimpot.

To track this fault down, I first connected a 100nF capacitor across the output of the first IF amplifier just prior to the ceramic filters. The idea here was that this would act as a short circuit for the IF signal. The crackling remained, so that meant that the fault was likely to be in the vicinity of the ceramic filters. Just to be sure, I then placed the 100nF capacitor across the output of the ceramic filters and the crackling disappeared.

I then remembered a similar problem that I had encountered in the past, when leaking electrolyte from a faulty capacitor had caused just the sort of crackling I was hearing. What's more, the ceramic filters in the set I was working on were adjacent to the leaking capacitor I had replaced earlier and it was quite possible that some of the goo had spread out under one or more of them.

That meant that all three filters had to come out so that the board could be properly inspected. Removing them from the closely packed board was a bit of a challenge to say the least. Two of them were small black rectangular blocks with five pins, while the third was a much larger device with a pair of pins at each end and a ground pin for the metal case.

Eventually, I was able to remove the three filters without damage to the board and wasn't surprised to see that some of the black goo had spread under the filter closest to the electro. Some more cleaning with IPA ensued, followed by a blow-off with compressed air. The filters were then reinstalled and the board put back into the chassis.

Powering up the radio now resulted in just the expected noise from the speaker without any of the crackling. So I'd nailed it!

A quick check with a signal generator set to 50µV showed that the receiver's gain was now back to what was expected. While I was at it, I adjusted the signal strength meter to read S9. This is the standard setting for a 50µV signal at the antenna terminals for HF amateur radio receivers.

The old Kenwood TS-450S transceiver now works well and is a useful addition for contacts on the HF amateur bands. SC

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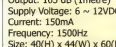

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18 x 3mm Rare Earth Magnets

* Rare Earth Magnets
* External Diameter:18mm
* Height 3mm
* Magnet Type: Button
* Material :Neodymium Iron Boron
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6mm Stud Copper Lug 2.5mm Cable

Device:DX 2.5-6
* Heavy Duty Crimp Lug
* Electro Tinned
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Suits: 2.5mm2 cable
Overall length: 21mm
Manufacturer:Davico

#44189

$4.00

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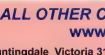
10A 250VAC IP65 Adjustable Rod Limit Switch



Device:TZ-8107
* Operating Force 750g
* 1 NO & 1 NC Contacts
* Overall Length: 205mm
* IP65 Rated
Manufacturer:Bonza

#44190

$3.00

7 Colour Cycle Auto Slow Sequence 5mm LED

Device:BK56RGBSC-S
* Built In Controller Chip
* Resistor Required To Limit Current To 20mA
* Lens:Water Clear
Manufacturer:HI Led

#43788

$5.00 *(Pack of 25)*

50Amps 1000V Bridge Rectifier.

Device:KBPC5010
Amps:50A
Voltage: 1000V
RoHS:Yes
Manufacturer:SEP

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Output: 105 dB (1metre)
Supply Voltage: 6 ~ 12VDC
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Size: 40(H) x 44(W) x 60(D)mm

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12VDC Coil DPDT Relay

Device:HRS2H-S DC12V
Coil Volts: 12VDC
Contact Form:2 Form C (DPDT)
Contacts:24VDC/125VAC 1A
Coil Resistance: 320 Ohm
Size(LHDmm):20.3 x 11.4 x 9.9mm
RoHS: Yes
Manufacturer:Multicomp

#43551

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The alarm unit sits inside the safe and sounds an alarm if the safe door is opened unless the correct code is entered before the entry delay period expires.

Hotel safe alarm for travellers

Design by JOHN CLARKE

Are you a frequent tourist? Then you will be familiar with the small safes in every room in most hotels and in the cabins on cruise ships. This Hotel Safe Alarm tells you if the safe has been opened in your absence and will also give the offender a very bad feeling that he or she has been detected. Their natural reaction will be to close the safe and abscond immediately.

ANYONE WHO regularly travels on cruise ships or stays in hotels will be familiar with the ubiquitous room safe which is usually inside the wardrobe. The safe has a 4-digit LED display and a numeric keyboard to let you enter a 4-digit code before closing it and again when you wish to open it.

They are very handy but it would be naive to think that these safes offer a high degree of safety for your valuables. After all, if you forget the code or the safe malfunctions, it is a straightforward exercise for the hotel staff to open them. That means that there could be people lurking about in hotel or ship corridors that don't have your best interests at heart. And since they will attempt their nefarious activity while you are absent, how can you discourage them? The answer is to use our Hotel Safe Alarm.

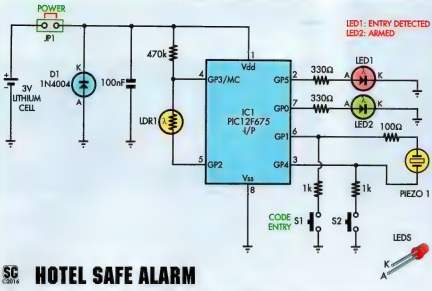
Of course, you could also use this alarm in a safe at home, or in a filing cabinet or desk drawer that you want to monitor. And you could use it to monitor a tool cupboard, pantry (against hungry teenagers marauding at night?) or whatever.

The Hotel Safe Alarm is a small plastic box with two LEDs (red and green) and two pushbutton switches. A light dependent resistor (LDR) detects when the safe has been opened and it will react to room lighting or a torch. A LED starts blinking immediately and if you don't enter in a code via the two buttons within 15 seconds, the inbuilt piezo transducer will start screaming at you (or the offender).

The duration of the alarm is 60 sec-

Features

- Powered by a lithium button cell
- Armed indication (green LED2)
- Entry indicator (red LED1)
- Piezo alarm
- Low current drain
- Adjustable entry delay period
- Adjustable alarm period



HOTEL SAFE ALARM

Fig.1: the circuit is based on PIC microcontroller IC1, light dependent resistor LDR1, a couple of LEDs and a piezo transducer. If the safe is opened, LDR1's resistance goes low and pulls pin 4 of IC1 low to start the alarm entry timer. The correct code then has to be entered within 15 seconds via pushbutton switches S1 & S2 to stop the alarm from sounding.

Specifications

- **Power:** 3V at typically 2.5µA
- **Alarm current:** 0.5mA
- **Alarm entry delay:** adjustable from 1-60s in 1s steps; initial value is 15s
- **Alarm period:** 10s to 120s, in10s steps. Default value is 60s
- **Alarm disable code:** any code sequence from one to eight switch presses
- **Alarm signal:** 280ms bursts of 4-6kHz tone with a 220ms gap between bursts

onds as the default setting but this can be set to between 10 seconds and 120 seconds, in 10-second increments.

If your safe has been opened in your absence, the alarm will indicate that by alternately flashing the red and green LEDs. To clear this alarm condition, you just feed in the entry code by pushing the two buttons in the normal way.

We'll describe how you enter the code and various time settings later in this article.

Circuit details

The circuit is very simple; just an 8-pin PIC microcontroller, two LEDs, two pushbuttons and few other components – see Fig.1. It is powered by a 3V lithium button cell and is switched on via jumper link, JP1. This can be removed when you are not using the alarm, to save the battery.

IC1 is a PIC12F675-I/P microcontroller and it is programmed with a tricky bit of software that lets you enter the necessary settings with only two pushbuttons. Normally, IC1 is in sleep mode and its watch-dog timer wakes it about every 2.3 seconds and it briefly checks the ambient light via the LDR, as follows.

Normally, IC1's GP2 output at pin 5 is set high (at 3V), so there is no current flow through the 470kΩ resistor and the LDR. This is done to minimise current drawn from the 3V cell. When IC1 wakes up, it sets GP2 low (0V) and then monitors the voltage at input GP3 (pin 4).

In darkness, the LDR resistance is high (well above 1MΩ) so the voltage at pin 4 will be high, at close to 3V, so IC1 (yawn) goes to sleep again. If it wakes and the LDR is exposed to ambient light, its resistance will be much lower, perhaps as little as 10kΩ in bright light. So the voltage at pin 4 will be low and IC1 starts to get excited. Well, perhaps not but it starts flashing green LED2 to indicate that the alarm is about to start sounding.

Provided the valid code is now entered with the two pushbuttons during the 15-second delay period, the alarm is disabled. If no code or an invalid code is entered, the piezo transducer sounds, as pins 6 & 3 (GP1 & GP4) alternately go high and low, to deliver bursts of 4kHz signal. In the confined space of a hotel safe and at close quarters, this can be quite loud.

Certainly, there is no mistaking that

Parts List

1 double-sided PCB, code 03106161, 61 x 47mm
1 front panel label, 74 x 47mm
1 UB5 translucent clear or blue case, 83 x 54 x 31mm
1 20mm button cell holder (Jaycar PH-9238, Altronics S 5056)
1 CR2032 lithium cell (3V)
2 SPST PCB mount snap action switches (Jaycar SP-0723, Altronics S 1099) (S1,S2)
1 30mm diameter piezo transducer (Jaycar AB-2440, Altronics S 6140)
1 10kΩ light dependent resistor (Altronics Z 1621; Jaycar RD-3480) (LDR1)
1 DIL8 IC socket
2 M3 tapped 12mm spacers
2 M3 tapped 6mm spacers
6 M3 x 6mm machine screws
2 M3 x 6mm machine screws
2 M3 x 6mm countersink screws
1 2-way pin header (2.54mm pin spacing) (JP1)
1 jumper shunt
2 PC stakes
1 25mm length of 2mm diameter heatshrink tubing

Semiconductors

1 PIC12F675-I/P programmed with 0310616A.hex (IC1)
1 1N4004 diode (D1)
1 3mm red high brightness LED (LED1)
1 3mm green high brightness LED (LED2)

Capacitor

1 100nF 63V or 100V MKT polyester or ceramic

Resistors (0.25W, 1%)

1 470kΩ	2 330Ω
2 1kΩ	1 100Ω

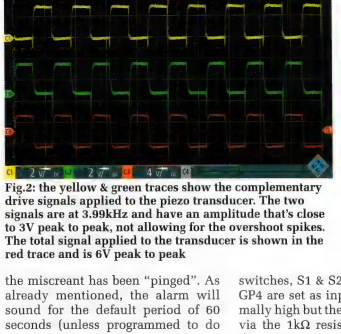


Fig.2: the yellow & green traces show the complementary drive signals applied to the piezo transducer. The two signals are at 3.99kHz and have an amplitude that's close to 3V peak to peak, not allowing for the overshoot spikes. The total signal applied to the transducer is shown in the red trace and is 6V peak to peak

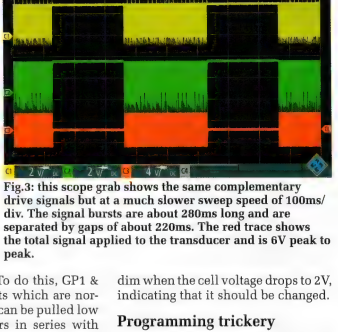


Fig.3: this scope grab shows the same complementary drive signals but at a much slower sweep speed of 100ms/div. The signal bursts are about 280ms long and are separated by gaps of about 220ms. The red trace shows the total signal applied to the transducer and is 6V peak to peak.

the miscreant has been "pinged". As already mentioned, the alarm will sound for the default period of 60 seconds (unless programmed to do otherwise).

The scope screen grabs of Fig.2 & Fig.3 show the complementary drive signals applied to the piezo transducer. In Fig.2, the two signals are at 3.99kHz and have an amplitude very close to 3V peak-to-peak, not allowing for the overshoot spikes. Therefore the total signal applied to the transducer will be very close to 6V peak-to-peak or about 3V RMS as shown in the red trace of Fig.2.

Fig.3 shows the same complementary drive signals but at a much slower sweep speed of 100ms/div. This shows the signal bursts which are about 280ms long and separated by gaps of about 220ms.

If the safe door is hastily closed again, the alarm will continue to sound for the remainder of the 60-second period and then go back to sleep. When the safe door is re-opened, the red and green LEDs will alternately flash for 15 seconds, unless you enter the valid code. If not, the piezo alarm will begin beeping again. And so the cycle goes . . .

So as well as providing some deterrent by sounding the alarm if a valid code is not entered, it will also tell you that the safe has been opened in your absence, even if it has been closed after being detected.

Button detection

As well as providing the drive signal for the piezo transducer, pins 6 & 3 (GP1 & GP4) monitor the state of the two momentary contact pushbutton switches, S1 & S2. To do this, GP1 & GP4 are set as inputs which are normally high but they can be pulled low via the 1kΩ resistors in series with the switches. So if S1 is closed, pin 6 (GP1) will be pulled low.

The 1kΩ resistors are included so that pressing the switches when the alarm is sounding will not short out the alarm signal to the piezo transducer.

Battery power

As already noted, the circuit is powered by a 3V button cell, via link JP1. When IC1 is in sleep mode, the current is quite low, at about 2.5μA.

The current drain when the piezo alarm is sounding is 0.5mA. And while LED2 is flashing, the current is 1.5mA (for a cell voltage of 3V).

Diode D1 is included as a safety measure to prevent damage to IC1 should the cell be connected incorrectly somehow. If the polarity is wrong, D1 will shunt the reverse current.

Reverse cell polarity could happen if the cell holder is installed the wrong way round. Alternatively, if the cell holder is installed correctly, then the diode protects the circuit if the cell is installed incorrectly. Note that for the particular cell holder we used, there is no way the cell can be inserted incorrectly and make a connection to the circuit.

IC1's power supply is bypassed with a 100nF capacitor and IC1 runs using its internal 4MHz oscillator which is shut down during sleep mode.

LED2's brightness provides an indication of the cell voltage. At 3V supply, LED2 is quite bright but will be dim when the cell voltage drops to 2V, indicating that it should be changed.

Programming trickery

Note that the GP3 input of the PIC12F675 is usually configured as the MCLR input (master clear), which allows the microcontroller to have an external power-on reset. However, for our circuit we need to use this as a general purpose input for monitoring the LDR.

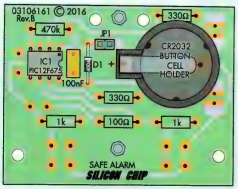
When MCLR is set up as an input, the MCLR operation is switched to an internal connection within the microcontroller so the master clear power-on reset function is not lost.

One disadvantage of using the MCLR pin as a general purpose input is that there can be a problem when programming the microcontroller. This occurs when the internal oscillator is also used to run the microcontroller (which we do). Similar to the Fridge Door Alarm presented in the April 2016 issue, we solved this problem in the software, as discussed in the programming panel.

PCB assembly

The parts are all installed on a small double-sided PCB coded 03106161 (61 x 47mm). This fits inside a small (UB5) plastic case. Note that the LEDs, switches, LDR and the piezo transducer are mounted on one side of the PCB, while the remaining components are mounted on the other side.

Fig.4 shows the parts layouts for both sides of the PCB. Begin construction by installing the resistors, using a multimeter to check the value of each before inserting it into place. Table 1



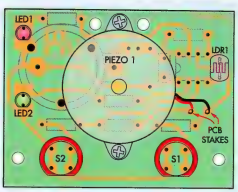
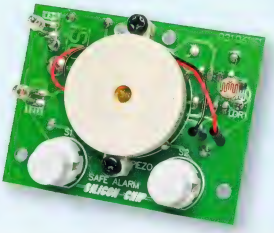


Fig.4: the PCB layout diagram on the left shows how the parts are mounted on the rear of the board, while the layout at right shows the how the parts are mounted on the top side. Take care to ensure that all polarised parts are correctly orientated and note that the piezo transducer is supported on 6mm spacers and secured with M3 screws – see text.



The PCB should only take about 30 minutes to assemble. Note that the LDR and the two LEDs must be mounted proud of the PCB – see text.

also shows the resistor colour codes.

Diode D1 can now be installed, taking care to orientate it correctly, then fit the IC socket, orientating its pin notch as shown in Fig.4. The 100nF capacitor is soldered in next and it can be positioned either way round. Then solder in the 2-way pin header for JP1 along with the cell holder. Make sure the plus terminal is orientated towards diode D1 on the PCB.

LED1 (red) and LED2 (green) are mounted so the top of the LED lens is 14mm above the top surface of the PCB. Make sure the longer lead of each LED (the anode) is inserted in the "A" position on the PCB. The LDR is also mounted 14mm above the PCB surface.

Once the LEDs are in, install switches S1 & S2, again taking care to ensure that they are correctly orientated (flat side positioned as shown).

Piezo transducer mounting

The piezo transducer is mounted off the PCB, supported on M3 x 6mm spacers and secured with M3 screws. The mounting holes in the lugs of the piezo transducer will need to be drilled out to 3mm for these screws. The wires are soldered to the PC stakes marked "piezo" on the PCB.

We used PC stakes for the piezo transducer wiring as this allows heat-shrink tubing to be slid over the wires and PC stakes to help prevent the wires from breaking off.

While the piezo transducer may have red and black wires, the polarity of the connections is immaterial; you can connect it either way around.

If you intend to program the PIC yourself, the file 0310616A.hex can be downloaded from the SILICON CHIP website. Check the programming panel on the following page for details on how to do this. Alternatively, you can purchase a pre-programmed PIC from the SILICON CHIP Online Shop.

Be sure to insert IC1 into its socket with the correct orientation and make sure you don't bend the pins under the IC. Then install the CR2032 cell in its holder and place the jumper link onto the 2-way header (JP1). If all is well, LED2 will begin to flash on and off after about three seconds, indicating

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	470kΩ	yellow violet yellow brown	yellow violet black orange brown
❑	2	1kΩ	brown black red brown	brown black black brown brown
❑	2	330Ω	orange orange brown brown	orange orange black black brown
❑	1	100Ω	brown black brown brown	brown black black black brown

Programming The PIC Micro

A programmed PIC for this project can be purchased from our on-line shop (www.siliconchip.com.au) or you may program one yourself. The software is also available from our website.

If you are programming the microcontroller yourself, you may be presented with a warning by the programmer stating that programming is not supported when both the MCLR pin is set as a general purpose input and the internal oscillator is used. As with the Fridge Door Alarm presented in the April 2016 issue, you will be able to program the microcontroller successfully, so ignore this warning. That's because any problems associated with this configuration is already solved by a software solution. Read on if you want more details.

As mentioned, we set MCLR as a general purpose input and utilise the internal oscillator within IC1. This can present problems for a programmer during the process of verifying the software code after programming.

The problem lies in the fact that as soon as the microcontroller is programmed, it will begin executing its program. A typical program initially sets up the microcontroller with the general purpose lines set as inputs or outputs (I/O). This conflicts with the programmer needing to use the clock and data programming I/O lines for program verification.

This problem does not happen if the MCLR pin is set as the external MCLR input because the programmer then has control over the microcontroller, stopping it from executing the programmed code.

Note also that in order to run the code, the microcontroller has to have the internal oscillator configured instead of an external crystal, RC or external clock oscillator.

The programming problem is solved in the software provided by including a 3-second delay at the start of the program. This delay is before the I/O lines are set as inputs or outputs. The I/O lines therefore remain as high-impedance inputs while the programmer verifies the internally programmed code using the clock and data programming lines.

A warning from the programmer will still be issued but the microcontroller can be programmed successfully and correctly verified by the programmer.

Note that the PIC12F675 also needs special programming due to the fact that it has an oscillator calibration value (OSCAL) that is held within the PIC's memory. This calibration value is individually programmed into each PIC by the manufacturer and provides a value that sets the PIC to run at an accurate 4MHz rate using the internal oscillator.

This value must be read before erasure and programming so that it can be included with the rest of the code during programming. If this procedure is not done, then the oscillator could be off frequency and that will have an effect on the Hotel Safe Alarm's sound.

Most PIC programmers will automatically cater for this OSCAL value but it is worthwhile checking if your programmer correctly handles this, especially if you have difficulties. Finally, be aware that the PIC12F675 requires a 5V supply for programming, even though it happily runs from 3V in the circuit.

that the LDR is exposed to light. The piezo transducer will then sound the alarm after the (default) entry delay period of around 15 seconds.

Plastic case

The PCB is installed inside a UB5 plastic case with the piezo transducer arranged to "fire through" a hole in the lid. You need to drill holes in the lid for the two LEDs, LDR, two switches and the piezo sound exit hole. In addition, two mounting holes, one either side of the two switches, are needed to secure the PCB to the lid, using spacers and screws.

The holes for the two LEDs and two PCB mounting holes adjacent to S1 & S2 are 3mm, the switch holes and piezo sound exit hole are 10mm and the LDR hole is 5mm. The drilling template (Fig.5) can be downloaded from the SILICON CHIP website (www.siliconchip.com.au).

Having drilled the holes, the label can be attached. This can be downloaded from the SILICON CHIP website, printed out (preferably onto photographic paper) and affixed to the lid using either glue or neutral-cure silicone.

Another option is to print the panel onto either an A4-size "Dataflex" sticky label (for ink-jet printers) or a "Datapol" sticky label (for laser printers) and directly attach this to the case lid. These labels are available from http://www.blanklabels.com.au – see accompanying panel.

Once the label is in position, cut out the holes using a sharp hobby knife.

The PCB is stood off from the lid of the case using M3 x 12mm tapped spacers. M3 screws secure the PCB to these stand-offs, with countersink screws used to secure the spacers to the lid. Finally, attach the lid to the case using the four screws supplied with the case.

Note that you can keep tabs on the condition of the lithium battery condition by observing LED2. If it flashes brightly, the cell is OK. As the cell discharges, the LED will become quite dim.

Changing the settings

There are three settings that can be altered on your Hotel Safe Alarm: entry delay, alarm duration and the entry code. **These can only be altered after switching the alarm off by removing link JP1 and then pressing one or both switches while JP1 is reinstalled to connect power.**

Changing the entry delay and alarm period are optional and you can leave them at default settings of 15 and 60 seconds, respectively. However, you will need to set the entry code.

Entry delay

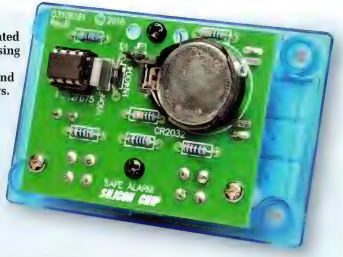
To set the entry delay, power the unit off by removing link JP1 and hold switch S1 down while JP1 is installed. Continue holding S1 down until you get a short beep from the piezo transducer (after about three seconds). Release S1 and another beep will sound.

The delay period is now entered by pressing switch S2. This starts from one second (plus the initial wake-up time of 2.3 seconds) and each time you press S2 there is a very brief double beep from the piezo to indicate the entry delay has been incremented by one second.

You can increase the delay to 60 seconds but we think that 15 seconds is quite adequate. You then store the entry delay setting by pressing S1 and this will be indicated by a short beep from the transducer.

Alarm period

The alarm period setting process is very similar to the entry delay but



The PCB is mounted on the case lid using two M3 x 12mm tapped spacers and M3 x 6mm screws.

now we do it with switch S2. So to set the entry delay, power the unit off by removing link JP1 and hold switch S2 down while JP1 is installed. Continue holding S2 down until you get a short beep from the piezo transducer (after about three seconds). Release S2 and another beep will sound.

The alarm period is entered by pressing switch S1. The alarm period starts at 10 seconds and each time you press S1 there is a very brief beep from the piezo to indicate that the alarm period has been incremented by 10 seconds.

The alarm period can be adjusted from between 10 and 120 seconds in 10-second steps. When S2 is pressed, the entered alarm period will be stored and indicated by a short beep from the piezo transducer.

Entry code

The entry code comprises a sequence of presses of S1 & S2. It can be as simple as 1, 2 or 2, 1 or it could be up to eight presses, such as 1 2 2 2 1 2 1 2. Most people will want to keep it reasonably short so that it is easily remembered, such as 1221. But it can be any sequence from 1-8 presses.

To set the entry code, power the unit off by removing link JP1 and hold both switches S1 and S2 down while JP1 is installed. Continue holding S1 & S1 down until you get a short beep from the piezo transducer (after about three seconds). Release S1 and S2 and another beep will sound.

The entry code is now entered in, with each switch press acknowledged by a brief piezo beep. The entered code will be stored after both switches are left open (ie, after none are pressed) for five seconds. An acknowledgement beep then sounds.

Using the alarm

The correct code needs to be entered during the entry delay period. Do not try to enter the code too quickly. Each time you push a button you need to wait for a short beep and then you press the next button. So for example, if your code is 1221, you do it in this sequence: 1 beep, 2 beep, 2 beep, 1 beep. If the code is correct, the alarm will not sound (the green LED stops flashing as soon as a switch is pressed).

If you make a mistake while entering the code, or you enter it too rapidly, the alarm will sound and the safe can be closed to muffle the alarm sound.

Entering the valid code prevents the alarm sounding only if no more switches are pressed. Any further button pressing following the valid code will be greeted by an alarm.

If an intrusion is detected, both LEDs will be flashing. They will cease flashing once one of the switches is pressed to begin the entry code sequence. The LEDs turning off may even give an intruder a false hope that the code entered was correct.

The alarm is rearmed after it is placed in darkness, ie, when the safe door is closed. As soon as light shines on the LDR, you have to enter the code to stop the alarm from sounding. SC

Front Panel Labels

The front-panel label can be made by downloading the relevant PDF file from the SILICON CHIP website and then printing it out onto photographic paper. It can then be attached to the front panel using silicone adhesive.

Alternatively, you can print onto a synthetic Dataflex sticky label if using an inkjet printer or onto a Datapol sticky label if using a laser printer.

(1) For Dataflex labels, go to: www.blanklabels.com.au/index.php?main_page=product_info&cPath=49_60&products_id=335

(2) For Datapol labels go to: www.blanklabels.com.au/index.php?main_page=product_info&cPath=49_55&products_id=326

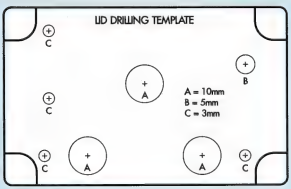


Fig.5: this drilling template can be downloaded as a PDF file from the SILICON CHIP website.

Fig.6: this front panel artwork is also available as a PDF file on the SILICON CHIP website (see panel).

Tecsun PL365 radio receiver

Readers may recall we included two new Tecsun portable radios in the "Product Showcase" section of the December 2015 issue. Due to space constraints, there were limited details but overall, both impressed us. We were contacted by a reader who liked the smaller of the new Tecsuns so much he bought one. Here's his report.

Want to listen in to the HF bands and also sample some of the local radio stations when travelling overseas? I was looking for an ultra-portable radio receiver with AM, FM, shortwave and hopefully single sideband (SSB) that would not take much room in my airline luggage.

The smallest radio I could find which fit the bill was the pocket-sized Tecsun PL-365, which is about 50mm wide by 159mm high and 25mm deep. It's the latest release from Tecsun, replacing the PL360 which was almost identical in appearance but lacks SSB.

This little radio looks a bit like an old FM "walkie-talkie", and does have a handy belt clip provided on the back of the case. It apparently uses the same Si4735 processor as its big brother, the PL-880 (costing nearly three times the price) and the performance of this little radio is quite pleasing for something so small!

The radio fits comfortably in the hand or even the shirt pocket and if you are right handed the two thumbwheels for volume and tuning are ergonomically positioned in just the right spot. Most of the other menu controls are on the front of the radio, just under the orange backlit screen positioned at the top of the receiver. The lower part of the case houses the three "AA" batteries required.

Tuning is via the thumbwheel or by using the "Easy Tuning Mode" (ETM) which seeks out the strongest stations and locks them into memory (there's enough memory for 550 stations).

I found this easy to use and it will be quite handy on the MW and VHF (FM) bands, to pick up local stations when travelling. Coverage is from 150 to 29999kHz while the FM band starts a little lower than the Australian band, covering 76 to 108MHz.

by Andrew Mason

MW tuning can be set to either 9 or 10kHz increments, all handy features if travelling overseas. Either way, it certainly was quick to thumb the "ETM" button and lock in all the strong FM stations in a moment. FM Stereo is available through headphones and a display on the LCD screen indicates this.

The LCD screen can provide a good deal of information, including the time, local temperature, memory functions as well as signal strength and signal-to-noise, displayed in dB. When any button is pressed the screen illuminates for a few seconds with a backlit orange glow which is quite useful in low light.

The PL-365 comes with several accessories: a soft pouch, a pair of 'bud' style earphones, a four metre wire antenna which clips to the whip to improve shortwave reception and a 'high sensitivity AM antenna' which is a bar antenna fitted with a small phono jack. This inserts in the top of the radio next to the headphone socket.

I found the local reception on AM to be perfectly adequate without the bar antenna – but it did boost the signal by several dB when I plugged it in. In practice, I could only "see" the signal had become stronger on the meter – I didn't notice any change in the audio, but that was on a local station anyway.

In my area the AM band is fairly crowded and I have not used the bar antenna. This high sensitivity antenna

Accessories include a soft case, ear buds, long wire antenna and a directional AM antenna (top centre), shown in situ in the photo below. I noted extra strength on the meter but to be honest, didn't notice much difference to the ear.

would be much more useful for DX stations and could also be used to enhance selectivity by twisting it to receive one station over another. Of course you could also use the socket to connect a different AM antenna, so long as you fitted it with the appropriate 3.5mm plug.

The main reason I purchased this radio was that it had continuous SW reception and included SSB. Pressing the SSB button selects the upper sideband, pressing it again selects the lower. I tried the receiver on the 20 metre band in the afternoon when it was opening and was pleased to hear an Italian amateur station coming through strongly.

The inbuilt telescopic whip antenna works well for both FM and SW but adding the extra 10m wire antenna did improve reception further on SW. Moving around or trying to run the wire in different directions can have an effect so it may be worthwhile to play around here.

On SW the frequency is displayed in kHz at the bottom of screen. In SSB mode pressing the 'display' button cycles through various options for additional information including showing signal strength for a few seconds before returning to side-band setting.

A beat frequency oscillator (BFO) is provided to tweak the sideband. I found most times this was unnecessary but it is very useful to have and I did use it a couple of times to improve readability of some stations (to near perfect tone). Pressing the BFO button causes the feature to flash on the screen and turning the tuning thumbwheel adjusts the setting. The method is the same for any of the menu buttons.

The wire antenna is fitted with a clip designed to attach to the telescopic antenna, while a spring-loaded plastic clip is provided at 'the high end' to attach to some suitably lofty point.

Because the radio itself is so small and light, the antenna wire can pull it over, through its own weight or in the merest breeze. This is not a problem if you're holding the radio but is something to be aware of if you place the receiver down on a table.

A close-up of the display and pushbutton controls. Both are excellent.

On the side of the radio is a mini-USB port which can accept 5V power from a PC or one of those ubiquitous USB chargers (not supplied). The radio uses three AA batteries and if you're using rechargeable Ni-MH batteries you can charge them in the radio by using the USB input and holding the charge button until 'CHR ON' displays.

I use alkaline batteries as I find they have longer shelf life than rechargeable batteries while I'm travelling. The battery cover did seem a bit flimsy and the small lugs, or notches in the plastic which hold it in place did not fill me with confidence that they would stand much abuse so changing batteries should be done with care. Perhaps rechargeables would be better in that way, in that you would have to open the back less often if you charge them in-situ.

I compared the PL-365 with another Tecsun portable I have, the larger PL-600. The tone of the larger radio is obviously far superior because it has a much bigger speaker than the PL-365, which is necessarily small in such a compact radio. That said, the sound from the 40mm speaker is not too harsh and is perfectly audible.

While the PL-600 has a slightly longer telescopic antenna I found the little PL-365 to be fairly comparable in reception when using both radios with just their inbuilt antennas alone. While the PL600 has a local/DX and wide/narrow settings which the smaller radio doesn't have, I found the little PL-365 to have pretty good sensitivity and selectivity and this might be down to the design (which includes the Si4737 DSP chip from Silicon Labs in the USA).

The published specs state that selectivity is better than 60dB across all the bands and sensitivity on SSB is less than 3μV.

For what it is, the PL-365 is a pleasing little receiver; it has good coverage and useful functions in a very small and lightweight package. It's perfect for travelling when you can't take a bigger rig with you and retailing for under $90, it promises to fill a gap for the shortwave enthusiast who likes to travel by plane.

The Tecsun PL-365 is available from Tecsun Radios Australia, www.tecsunradios.com.au and retails for $88.00. SC

The budget Senator Loudspeaker System . . .

. . . finishing them off

By Leo Simpson

In this second and final article on Budget Senator speakers using the Altronics C3026 10-inch woofer, we complete the assembly details, including the crossover network PCB and discuss hand-winding the 2.7 millihenry air-cored inductor.

Last month we described how to build the cabinets, either from scratch or based on the very attractive Bunnings Kaboodle modules. What remains to be discussed is mounting the drivers, assembly of the crossover network PCB and obtaining the 2.7mH air-cored inductors. You will need one for each Senator speaker.

Let's describe the inductors first. In the original Senator loudspeaker articles described in September & October 2015, we specified a 2.7mH air-cored inductor from Jaycar, Cat LF-1330. These were well made but unfortunately have now been discontinued by Jaycar.

Most constructors will want to buy their inductors and the easiest approach is to buy them from Australian audio company, Soundlabs, at www.soundlabsgroup.com.au

Soundlabs have three 2.7mH air-cored chokes, wound with 18 gauge, 16 gauge and 12 gauge enamelled copper wire. Most people would be happy with the 18-gauge model at $20 each, plus packing & postage. See www.soundlabsgroup.com.au/p/MU-AC2m7-1mm/2.7mH+-+0.90+DCR+1mm+Copper+Air+Core+Coil+18AWG

Buyers from overseas might want to consider a similar product from Jantzen Audio, available from Parts Express at www.parts-express.com/jantzen-audio-27mh-18-awg-air-core-inductor-crossover-coil--255-272 or Amazon at www.amazon.com/Jantzen-Audio-2-7mH-Inductor-Crossover/dp/B0002M736A

And then there is the option to wind your own and save some money. We wound prototype inductors from 18-gauge enamelled copper wire and we have to state that it is not an easy task.

These 2.7mH chokes from Soundlabs are wound with different gauge wire and on different formers, hence the differences. The 18AWG types are $20 each +GST; the 12AWG are $65 + GST.

It would be easier to wind the inductors from 20-gauge wire since it is thinner and not so stiff but the resistance of the resulting coil would be a little higher: about 1.6Ω instead of close to 1.0Ω measured on our prototypes.

While high fidelity purists will no doubt argue that minimal inductor resistance is very important, the audible difference between inductors wound with 18-gauge and 20-gauge will be undetectable.

You can measure the very slight difference in bass response but you won't hear it.

But because many readers would probably take the purist approach and the cost difference between the required 20-gauge and 18-gauge wire is zero – you will need to buy a 1kg reel of wire in both cases – we plunked for the heavier gauge.

But that makes it harder to wind, unless of course, you have access to a coil winding machine!

First make your bobbins

Our first attempt to make a bobbin used a 25mm length of readily available PVC electrical conduit and two cheeks made with a hole saw from Masonite hardboard and then glued together.

That was OK but did not look particularly professional and the small diameter former made it very difficult to wind, because of its small radius.

In any case, when we wound on the calculated number of turns, the inductance was considerably less than the required 2.7mH. Hmm – that was annoying.

Our second attempt, pictured in this article, used a 1-inch length of 25mm OD electrical conduit and 67mm diameter cheeks cut from Perspex using a hole saw. We then glued them together with Bostik PVC Pipe Cement (Blue type N).

The larger diameter former made winding a little easier but it was still tricky. In fact, I aborted the second attempt which involved using a geared manual drill clamped in a vise.

It was just too hard to maintain the required winding tension while keeping the wire layers neat and keeping count of the number of turns.

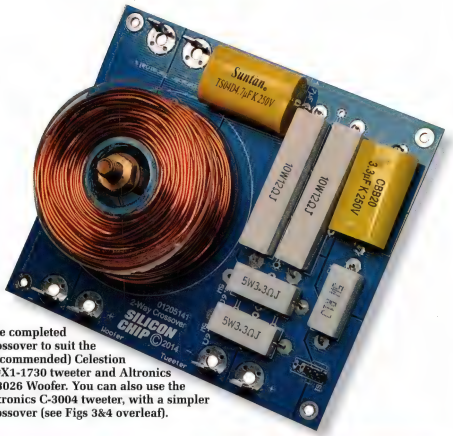
The method I finally used was to stretch the required 40 metres or so of 18-gauge wire from the back end of my garage and up the driveway and then slowly walk "along the wire" while I wound it onto the bobbin – while trying to keep the layers neat, keeping count and maintaining tension. It took about half an hour.

The finished result can be termed "workable" but is far less neat than an inductor produced on a coil winding machine.

And note that no matter how hard you try to keep the layers neat, the finished inductor will be "jumble wound", not "layer wound"!

By the way, if you go on-line to find a calculator for an air-cored inductor and feed in the parameters for the inductor we describe here, you will get a result of 295 turns.

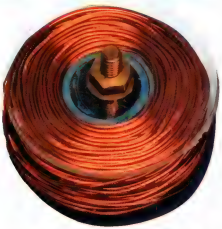
For example, see http://www.diyaudioandvideo.com/Calculator/AirCoreInductorDesigner/



The completed crossover to suit the (recommended) Celestion CDX1-1730 tweeter and Altronics C-3026 Woofer. You can also use the Altronics C-3004 tweeter, with a simpler crossover (see Figs 3&4 overleaf).

As already noted, we had to use more turns, specifically 325. Ideally, you need to measure the inductance although if you wind it using this method you should get a value within ±5%, which is close enough.

Still interested in winding your own? If so, we have produced a limited quantity of Perspex discs which can be glued up using a solvent-based plastic adhesive such as Sci-Grip Weldon at Acrylics Online: www.acrylicsonline.com.au/shop-product/accessories--adhesives/scigrip-ips-weld-on-16-clear-acrylic-cement



The inductor we hand-wound using 325 turns of 18 gauge wire, on a former cut from PVC conduit and perspex cheeks (using a hole saw). Ideally it should be "layer wound" ... but we found this almost impossible.

The discs can be aligned and held in place by a 1/4-inch or M6 bolt and nut (as pictured) but it is *most* important that when the finished inductor is mounted on the PCB, it must be secured with a brass bolt and nut.

Do not use a steel bolt otherwise the inductance will be substantially increase and the harmonic distortion will also increase due to the significant non-linearity of the B-H curve of steel. Brass is non-magnetic.

There is a trap for young players here: some "brass" bolts and nuts are actually brass-plated steel. If in any doubt, check to make sure your "brass" bolt will *not* be attracted to a magnet.

Just as an aside: some loudspeaker manufacturers use iron-cored inductors in their crossover networks. This is a second-rate option. Sure, it produces a more compact inductor with less turns of copper wire but the resulting inductor will be quite non-linear and can cause significant distortion.

Crossover network

There are two versions of the crossover network; which one you use depends on the speaker you choose.

The circuit of Fig.1 is the same as we used for the original Senator sys-

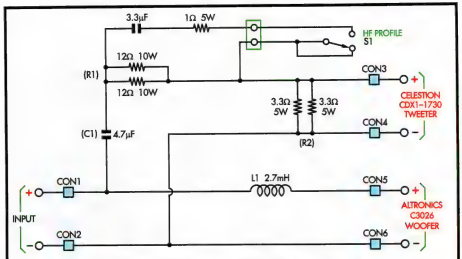


Fig.1: the crossover required for the Celestion tweeter and Altronics woofer.

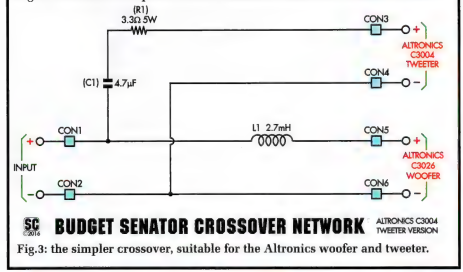


Fig.3: the simpler crossover, suitable for the Altronics woofer and tweeter.

tem described in September & October 2015 and you should use this if you are using the Altronics woofer and Celestion horn tweeter.

No changes are required, even though the Altronics woofer is slightly less efficient than the Celestion 10-inch woofer. The accompanying component overlay is shown in Fig.2.

On the other hand, if you take the cheaper option and elect to use both the Altronics woofer and tweeter, most of the attenuation resistors are omitted and the resulting crossover network is shown in Fig.3, together with its component overlay in Fig.4.

The most important aspect of assembling the crossover network PCB is to make sure you make good solder connections to the inductor. Make sure that you thoroughly remove the varnish from the ends of the wires and then tin them with solder. You will actually need to do this anyway, if you are going to check the inductance value.

Poke the inductor wires through the two holes on the PCB and then secure the inductor with a brass bolt, nut and washer. Then solder the two connections on the PCB. The rest of the assembly is straightforward.

Mounting the crossover PCB

While the crossover PCBs in the prototype Senators were installed behind the internal sloping panel inside the cabinet, we do not recommend this position as it would be virtually

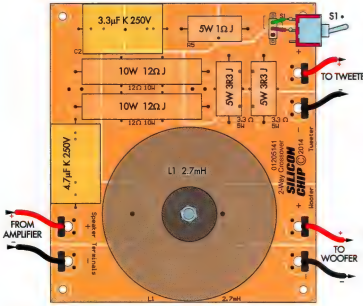


Fig.2: use this PCB overlay to assemble the crossover shown above (Fig.1) for the Celestion/Altronics combination

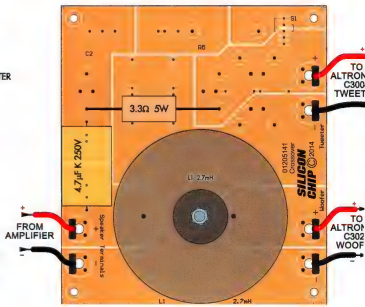
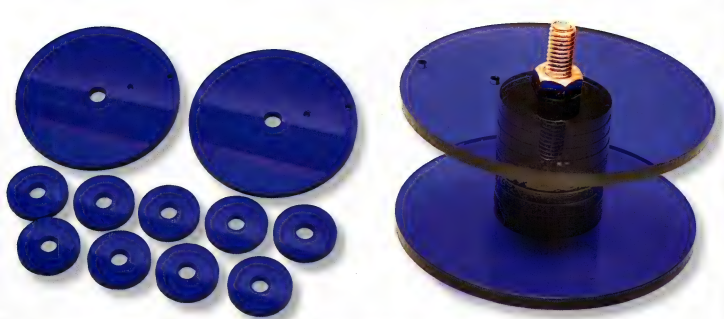


Fig.4: the crossover for the Altronics C-3004 tweeter and C-3026 woofer (Fig.3 above) requires fewer components.



Here's an alternative method of bobbin assembly: the two larger discs form the outer cheeks, while the nine smaller discs are stacked to form the bobbin core. Note the use of a BRASS bolt and nut – steel bolts are magnetic and will adversely affect the performance of your crossover. The SILICON CHIP on-line shop (www.siliconchip/com.au/shop) has a limited number of these accurately-machined bobbin assemblies (11 discs, no bolt/nut) available for $5 per pair plus p&p (currently $AU10).

impossible to remove the PCB if a fault subsequently developed.

Instead, we recommend mounting the crossover PCB in front of the sloping panel, on the floor of the cabinet, using four self-tapping screws. To connect the PCB, you need to crimp 6.3mm yellow female spade connectors onto the ends of the wires from the woofer and tweeter and plug these into the appropriate connectors on the PCB.

You also need some 400mm-long spade-lug to spade-lug cables using spare speaker wire off-cuts to connect the input terminals on the PCB to the binding posts mounted on the rear panel of the speaker.

If using the treble peaking switch (only applicable with the Celestion/Altronics combination), drill a hole through the rear panel of the speaker and wire the switch up to one of the pairs of terminals marked on the PCB (ie, the middle pin and one of the upper pins).

Alternatively, use a jumper shunt instead, shorting out the indicated pins to enable the treble peaking or placing it across the lower pins to disable peaking.

Mounting the drivers

This is relatively straightforward, except to note that you should use black (or even later painted black!) screws to mount the speakers.

Another important point is that it is vital that the speakers are air-tight when mounted.

It's not so much of a problem with the Celestion drivers but the Altronics will definitely need a layer of draft-exclusion tape between the case and driver to seal them.

Draft exclusion tape is available from hardware stores, etc. But ensure there are no breaks in the tape to allow air in/out.

Finishing off

Your Senator speaker box(es) are now complete and almost ready for use. However, we do not recommend using them "flat on the floor" as this will tend to make the bass "boomy".

Raising them by, say, 100mm or so will virtually eliminate this problem and as a bonus, will raise the tweeters up to a level which is more in line with a typical listening position.

Fortunately, Bunnings have an ideal solution to the problem, again intended for kitchen cabinets.

We bought sets of their "leggz" 100mm cabinet furniture legs, as seen below.

Each pack contains four legs so is suitable for one speaker box. Once fitted, they have the added advantage of being height-adjustable so can help fix any minor discrepancies in floor levels.

You simply screw the legs to the outer corners of your speakers, in (say) 100mm from the sides and front.

Sit back, relax with your favourite music . . . and enjoy!

Bunnings' "leggz" are intended for weighty furniture use so are ideal for the Senator speakers.

PARTS LIST

The complete parts list for the Budget Senator Speakers was published in Part One, last month

Queries on Celestion horn tweeter response

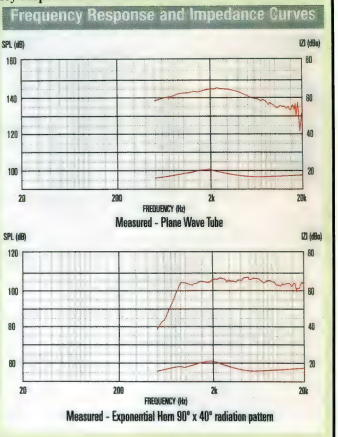
Recently, one of our readers queried the low level frequency response of the Celestion tweeter

I have been looking at the specs of the Celestion compression driver used in the Senator and Majestic speakers. Whilst the curves are excellent at high power levels, the lower levels don't look so good.

The compression driver is quite efficient and according to Celestion, intended for larger auditoriums where it can be driven at optimum power levels. Lounge rooms of the average family home being much smaller only need a fraction of these compression driver's capability to achieve a balanced SPL and therefore they would appear to be working in the poorest part of their performance envelope.

Perhaps an article on compression driver technology might be in order, as evidently their initial adoption by the US hifi market is spreading. Their use also puts the crossover frequency in the most psycho acoustic sensitive part of audio spectrum which is considered not best design practice. However if the performance figures of the Senator design using the Celestion drivers is true in audio listening then 3-way systems are a thing of the past. It also raises the question of driving woofer and tweeter from separate amplifier modules. This is not only energy efficient but with the crossover put into a small signal network I would think cost efficient too, especially if the two amps were on the same board. The power supply would just be the same rating.

Kelvin Jones,
Kingston, Tas.



Comment: You raise an interesting question. Both our frequency response curves and those by Celestion have been done at the standard power level of one watt. However the published curves from the Celestion brochure (reprinted above) are labelled in a confusing way and it would be easy to misinterpret them. In each case, the left-hand axis pertains to the upper frequency response curve and it is labelled as "SPL (dB)". SPL stands for "sound pressure level".

The right-hand axis pertains to the lower curve which is actually the tweeter's impedance and it is labelled "|Z| (dBo)". We interpret this to mean the "absolute" value of the impedance but it really should have been scaled and labelled in Ohms.

The lower curves do not refer to a frequency response at a lower power level.

Our measurements and listening tests have shown that this tweeter is very smooth at all power levels and in the case of the Majestics, performs beautifully up to 300 Watts RMS (250 Watts for the Senator), by dint of the attenuation resistors in the crossover network.

Also, the response will vary depending on the type of horn attached as you will note from the difference between the plane wave tube and the exponential horn. To obtain the most linear response and lowest harmonic distortion from any compression tweeter, it should fitted with an exponential horn, as we have specified.

By the way, the term "compression driver" refers to the fact that the diaphragm is "pressure loaded" by the attached horn. You cannot operate a compression driver without a horn. You can see a short description of compression drivers at https://en.wikipedia.org/wiki/Compression_driver

Nor does the term "compression driver" necessarily suggest that there is significant dynamic range compression although all loudspeakers are subject to some degree of compression due to heating of their voice coils and the resultant increase in their resistance.

Note that for home use and especially for home movies, the power handling ability of the Celestion horn tweeter is very useful because many DVDs and Blu-ray discs have program material with an enormous dynamic range, ie, a whisper is as silent as a whisper and a cannon can be as loud as a real cannon. This can distort and sometimes ruin tweeters with low power handling ability.

We agree that there is no advantage in having a 3-way system compared with the 2-way Majestic and Senator designs.

As far as driving the tweeter from a separate amplifier is concerned, it is true that you avoid the attenuation losses in the crossover network but they would be more than offset by the increased power consumption associated with having a separate Class-AB amplifier.

And of course, you would also need an active crossover network. We don't think it is worth the extra complication.

4367 Studio Monitor

For those who have admired the Majestic Loudspeaker (SILICON CHIP, June & September 2014) and the more recent Senator speakers (SILICON CHIP, September 2015) but who don't have the inclination or time to build these speakers, you could always consider a top-of-the-line commercial loudspeaker system of similar specification.

An outstanding example would be the newly released JBL 4367 Studio Monitor. It is a 2-way system similar in size, efficiency and power handling to the Majestic and also uses a 15-inch woofer and a large horn.

That is where the broad similarity ends though, as both the JBL woofer and tweeter have some exceptional features.

For example, the woofer has a large (1.5kg) neodymium magnet and two 3-inch voice coils on a common pole piece. Its free-air resonance is 28Hz.

And interestingly, the JBL compression driver has two annular diaphragms and a special wave-guide horn.

Both horn tweeter and woofer are coupled via a complex crossover circuit featuring 16 polypropylene capacitors, nine resistors and six air-cored inductors. All are mounted on a thick MDF board using point-to-point assembly. The crossover frequency is 700Hz. The enclosure itself is made from 1-inch thick MDF. Overall weight is 61.2kg.

The rated frequency response is 30Hz to 40kHz at the -6dB points and -10dB at 26Hz.

Convoy International, the national distributor for JBL, will be launching it at the upcoming International Hi-Fi show which will be held at the Pulman Hotel, Albert Park on July 1st–3rd.

Recommended retail price is a cool $25,990 per pair.

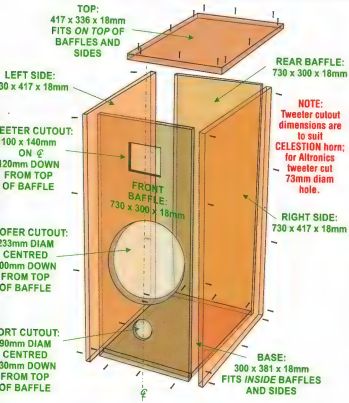
OOPS! Some of our dimensions didn't add up!

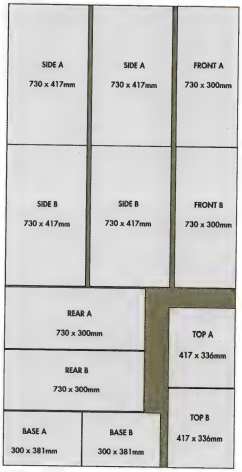
A reader queried the dimensions of the Budget Senators published in the May issue – according to him they didn't quite add up. And he was right!

For some reason, Mr Murphy changed the width of the base plate from 300 x 381mm to 320 x 381mm. "Only 20mm", you say. But that 20mm not only threw other dimensions out (eg, front and rear baffles) but meant that the cutting diagram also didn't make sense.

The important diagrams are shown here. Note that the only dimension which has changed is that 300mm width; everything else adds up when this is changed.

And best of all, the cutting diagram, which we knew should work, now really does work. You should be able to get all the pieces (except the reflector boards, as we mentioned last month) out of a single sheet of 2400 x 1200 x 18mm MDF with quite a bit of "meat" left over to account for saw thickness etc.





MATERIAL: 2400 x 1200 x 18mm MDF etc.

SILICON CHIP ONLINESHOP

.com.au/shop

Looking for a specialised component to build that latest and greatest *SILICON CHIP* project? Maybe it's the PCB you're after? Or a pre-programmed micro? Or some other hard-to-get "bit"? The chances are they are available direct from the *SILICON CHIP* ONLINESHOP.

As a service to readers, *SILICON CHIP* has established the ONLINESHOP. No, we're not going into opposition with your normal suppliers – this is a direct response to requests from readers who have found difficulty in obtaining specialised parts such as PCBs & micros.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, regardless of how many boards or micros you order! (Australia only; overseas clients – email us for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!

HERE'S HOW TO ORDER:

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- ✔ **Via the INTERNET (24 hours, 7 days):** Log on to our secure website – siliconchip.com.au, click on "SHOP" and follow the links
- ✔ **Via EMAIL (24 hours, 7 days):** email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details
- ✔ **Via MAIL (24 hours, 7 days):** PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details!
- ✔ **Via PHONE (9am-5pm EADST, Mon-Fri):** Call (02) 9939 3295 (INT 612 9939 3295) – have your order ready, including contact and credit card details!

YES! You can also order or renew your SILICON CHIP subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *SILICON CHIP ONLINESHOP* stocks microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12) Do Not Disturb (May13) IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies "2 chips – $15 pair." (Aug13), Driveway Monitor Receiver (July15) **Hotel Safe Alarm (Jun16)**
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14) Remote Mains Timer (Nov14), Driveway Monitor Transmitter (July15) Fingerprint Scanner (Nov15) MPPT Lighting Charge Controller (Feb16) 50/60Hz Turntable Driver (May16)
PIC16LF88-I/P	Garbage Reminder (Jan13), Beli\bird (Dec13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16LF1709-I/SO	Battery Cell Balancer (Mar16)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semitest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC16F1K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC16LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12), Touchscreen Audio Recorder (Jun/Jul 14)
PIC32MX170F256B-50I/SP	Micromite Mk2 (Jan15) – *also includes* **FREE** *47µF tantalum capacitor* Micromite LCD Backpack (either version) (Feb16), Parking Assistant (Mar 16)
PIC32MX170F256B-I/SP	Low Frequency Distortion Analyser (Apr15) Bad Vibes (June 15)
PIC32MX170F256D-I/PT	**100dB Stereo Audio Level Meter / VU Meter (Jun16)**
PIC32MX170F256D-50I/PT	44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14), Digital Effects Unit (Oct14)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
dsPIC33FJ128GP306-I/PT	CLASSIC DAC (Feb-May 13)
ATTiny861	V/IA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, HARD-TO-GET BITS, ETC

P&P – $10 Per order#

NEW THIS MONTH:
100dB STEREO AUDIO LEVEL/VU METER
All SMD parts except programmed micro and LEDs (both available separately) *(Jun16)* **$20.00**

RASPBERRY PI TEMPERATURE SENSOR EXPANSION
Two BS0150N03 dual N-channel Mosfets plus 4.7kΩ SMD resistor. *(May16)* **$5.00**

MICROWAVE LEAKAGE DETECTOR - all SMD parts: *(Apr16)* **$10.00**
BOAT COMPUTER - (REQUIRES MICROMITE LCD BACKPACK – $65.00 [see below]) *(Apr16)*
BOAT COMPUTER - VK2828U7G5LF TTL GPS/GLONASS/GALILEO module with antenna & cable: **$25.00**
BOAT COMPUTER - VK16E TTL GPS module with antenna & cable: *(Apr16)* **$20.00**

ULTRASONIC PARKING ASSISTANT (REQUIRES MICROMITE LCD BACKPACK – $65.00 [see below])
Ultrasonic Range Sensor **PLUS** clear lid with cutout to suit UB5 Jiffy Box *(Mar 16)* **$7.50**

BATTERY CELL BALANCER
ALL SMD PARTS, including programmed micro *(Mar 16)* **$50.00**

MICROMITE LCD BACKPACK *** COMPLETE KIT *******
includes PCB, micro and 2.8-inch touchscreen *(Feb 16)* *$65.00
VALVE STEREO PREAMPLIFIER - *(Jan 16)* **$30.00**
100µH SMD inductor, 3x low-profile 400V capacitors & 0.33Ω resistor

MINI USB SWITCHMODE REGULATOR Mk II all SMD components *(Sept15)* **$15.00**
ARDUINO-BASED ECG SHIELD - all SMD components *(Oct 15)* **$25.00**
ULTRA LD Mk 4 - plastic sewing machine bobbin for L2 – pack 2 *(Oct 15)* **$2.00**
VOLTAGE/CURRENT/RESISTANCE REFERENCE - all SMD components# *(Aug 15)* **$12.50**
includes precision resistor. Specify either 1.8V or 2.5V

MINI USB SWITCHMODE REGULATOR all SMD components *(July 15)* **$10.00**

BAD VIBES INFRASOUND SNOOPER - TDA1543 16-bit Stereo DAC IC *(Jun 15)* **$2.50**
BALANCED INPUT ATTENUATOR - all SMD components inc.12 NE5532D ICs, 8 SMD diodes, SMD caps, polypropylene caps plus all 0.1% resistors (SMD & through-hole) *(May 15)* **$65.00**
APPLIANCE INSULATION TESTER - 600V logic-level Mosfet, 5 x HV resistors: *(Apr15)* **$10.00**
ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: *(Jan15)* **$40.00**
all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors:
CDI – Hard-to-get parts pack: Transformer components (excluding wire), all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor: *(Dec 14)* **$40.00**
CURRAWONG AMPLIFIER Hard-to-get parts pack: *(Dec 14)* **$50.00**
LM1084IT-ADJ, KCS6603D, 3 x STX0504, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors
ONE-CHIP AMPLIFIER - All SMD parts *(Nov 14)* **$15.00**
DIGITAL EFFECTS UNIT WM8571 DAC IC & SMD Capacitors *[Same components also suit Stereo Echo & Reverb, Feb14 & Dual Channel Audio Delay Nov 14]* *(Oct14)* **$25.00**
AD9833ARZ Video Amplifier ICs For Active Diffrerential Probe (Pack of 3 SMD) *(Sept 14)* **$12.50**
44-PIN MICROMITE Complete kit inc PCB, micro etc *(Aug14)* **$35.00**
MAINS FAN SPEED CONTROLLER - AOT11N60, 600V Mosfet *(May14)* **$5.00**
RGB LED STRIP DRIVER - all SMD parts and BS0150N03 Mosfets, does not include micro (see above) nor parts listed as "optional" *(May14)* **$20.00**
HYBRID BENCH SUPPLY- all SMD parts, 3 x BCM856DS & L2/L3 *(May 14)* **$45.00**
USB/RS232C ADAPTOR MCP2200 USB/Serial converter IC *(Apr14)* **$7.50**
NICAD/NIMH BURP CHARGER *(Mar14)* **$7.50**
1 SPD15P10 P-channel logic Mosfet & 1 IPP230N06L3 N-channel logic Mosfet
10A 230V AC MOTOR SPEED CONTROLLER *(Feb14)* **$45.00**
40A IGBT, 30A Fast Recovery Diode, IR2125 Driver and NTC Thermistor

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*All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable; **# P&P prices are within Australia. 0'seas? Please email for a quote**

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PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB only – *not a full kit*. If you want a kit, contact the kit suppliers advertising in this issue. For more unusual projects where kits are not available, some have specialised components available – see the list opposite.

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01212111	$25.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01212112/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01011121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (New V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08109121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	15110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110121	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$45.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	11102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07106131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-455MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106132	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$15.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$10.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp (Sept'11)	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS (for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter board refer above [Nov 2012/May 2013])	DEC 2013	01111131-3	$35.00/set
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender Mk2	JAN 2014	01112131	$15.00

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
LI'l Pulser Mk2 Revised	JAN 2014	09107134	$15.00
10A 220VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$12.50
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16104141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMETER ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141a/b	$15.00
VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-PI AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	-	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
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Nicholas Vinen reviews Rohde & Schwarz new RTH1004 4-channel portable 'scope

Scope Rider

This 2/4-channel portable/desktop digital oscilloscope is one of the most generally useful test instruments that we have come across. It has four totally isolated input channels, each rated for 1000V (Cat III) or 600V (Cat IV) with the supplied probes, up to 300V offset between each channel, a bandwidth of up to 500MHz, optional 8-channel logic analyser and multimeter mode.

As you would expect, as new oscilloscope models are released, they tend to have more and better features than the last generation – not just more bandwidth, faster sampling and so on but also touch-screen interfaces, more mathematical display modes, more modes for measurement, analysis, triggering and so on.

But sometimes it's the seemingly simple features which come in most handy in day-to-day usage.

The first feature that caught our attention on the R&S Scope Rider is the four fully isolated inputs. You would expect the inputs in a portable scope to be isolated from the power supply but these are also isolated from each other.

To get the same facility in a desktop you need differential probes; a set of four such probes with the bandwidth of this unit would probably set you back more than the cost of this scope!

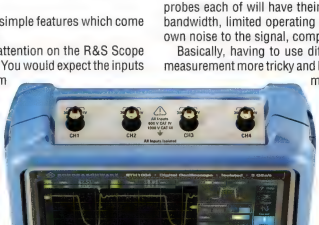
Why is this such a big deal? Well, there are a number of situations where you might need to examine signals which do not have a common ground.

For example, circuits with multiple ground domains or multiple reference voltages, signals with a DC offset where the offset may also contain AC components, measuring the voltage across high-side shunt resistors or emitter resistors, floating Mosfet gate drive signals, mains devices which switch the Neutral conductor and so on.

Spend any significant amount of time with a scope and you will run into one or more of these situations.

The usual solution is to break out a differential probe but this has many drawbacks: you need to own one or more differential probes each of will have their own power supplies, but limited bandwidth, limited operating voltage ranges but they add their own noise to the signal, complicate the wiring, etc, etc.

Basically, having to use differential probes generally makes measurement more tricky and less reliable (sometimes downright misleading).



There's also the fact that when you're dealing with low-level or high-frequency signals, you really need to connect the ground clips for each probe into the circuit and when doing so there's always the possibility you will clip onto to the wrong part of the circuit and short it out via the scope's Earth wiring, possibly damaging the device under test and maybe the scope too!

With fully isolated inputs, all these problems are eliminated. You simply connect each probe to the signal you're interested in and the "Earth" clip to its reference voltage (ground or whatever).

There's no possibility of shorting anything out, no loss of bandwidth –

The R&S Scope Rider has an 8-inch touchscreen, jog wheel and large buttons for control. The Ch1-4 buttons illuminate when a given channel is active while the timebase control buttons are immediately above and vertical controls below.

you just make the connections and measure the signals.

Isn't that what you really want from a scope?

Scope1 shows one real-world scenario that we came up with or this scope. Channels 1, 2 and 3 are connected across three cells in a fully charged Li-Po battery pack, hence they are each showing around 4.1V (with 2V/div), as confirmed by the measurement at upper left. We've staggered the vertical (ground) offsets or each channel so the traces don't obscure each other.

Channel 4 is monitoring the gate voltage of a P-channel Mosfet connected across cell #3. It is held high initially, keeping the Mosfet off. When the Mosfet switches on, it is pulled down to ground which is significantly below the Mosfet's source voltage, hence the trace goes negative.

Of course, you could monitor all these voltages using a traditional 4-channel scope with single-ended inputs but the voltage measurements for all but the bottom-most cell would require some interpretation and similarly, most Mosfet gate voltages would not be relative to their sources and so it may not be obvious whether they are on or off. The situation would be even more difficult if the voltages were not so steady, as is the case in some circuits.

To give another example, look at Scope2. It shows the piezo driver waveforms of the Hotel Safe Alarm described elsewhere in this issue.

The yellow and green traces show the complementary drive signals coming from the PIC16F88 microcontroller and these have the same common earth point. The red trace shows the summed drive signal across the transducer which is effectively being driven in bridge mode.

To get the same signal display in a typical desktop scope you would have to resort to a differential probe or the MATH mode (showing the difference between the complementary signals). On this portable scope, it's easy.

Finally, Scope3 and Scope4 show another situation where you would normally want a differential probe with a high isolation voltage.

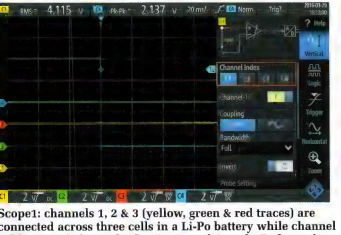
In this case we are showing the signal applied to a 230VAC LED down-light operating from a trailing-edge dimmer. Again, it's a simple connection and the very high common-mode rejection of the scope means that we can have faith in the accuracy of the displayed signal.

Resolution, sampling rate and waveform update rate

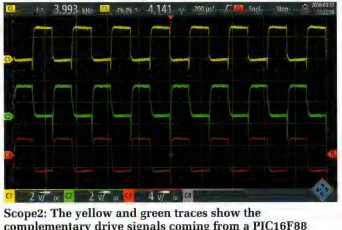
The next most impressive feature of this scope is the combination of 10-bit ADCs and the many different bandwidth options, selectable per-channel: 1/2/5/10/20/50/100/200/500kHz and 1/2/5/10/20/50/100/200/500MHz (the latter options available only on the higher-bandwidth models).

Basically, with a very wide bandwidth, there's enough noise that the 10-bit ADC provides little benefit.

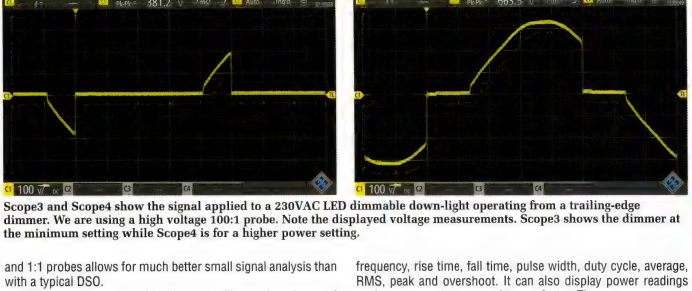
But once you reduce it below about 50MHz, the waveform becomes much cleaner and you can really see the advantage of the extra two bits giving 1024 different voltage steps rather than just 256. This, in combination with a 2mV/div sensitivity setting



Scope1: channels 1, 2 & 3 (yellow, green & red traces) are connected across three cells in a Li-Po battery while channel 4 (blue trace) shows the floating gate drive of a P-channel Mosfet connected across cell #2. The trigger is set to when the Mosfet switches on. Probe settings are shown at the top and bottom of the screen.



Scope2: The yellow and green traces show the complementary drive signals coming from a PIC16F88 microcontroller and these have the same common earth point. The red trace shows the summed drive signal across a piezo transducer which is effectively being driven in bridge mode.



Scope3 and Scope4 show the signal applied to a 230VAC LED dimmable down-light operating from a trailing-edge dimmer. We are using a high voltage 100:1 probe. Note the displayed voltage measurements. Scope3 shows the dimmer at the minimum setting while Scope4 is for a higher power setting.

and 1:1 probes allows for much better small signal analysis than with a typical DSO.

While some scopes provide a low-pass filter option, they tend to have very limited abilities with it switched on, such as reduced waveform update rate, no MATH operations and so on.

With this scope, you can choose a channel bandwidth as low as 1kHz and treat the result just like you would any other trace with no degradation in performance. This allows you to filter out noise and glitches you aren't interested in to better observe the actual signal.

It's especially useful when working with audio frequency signals.

The bandwidth choices in the range are 60MHz, 100MHz, 200MHz, 350MHz and 500MHz. Regardless of which you pay for, you get a 5Gsample/second scope.

This is shared between the channels so drops to 2.5Gsa/sec with two active and 1.25Gsa/sec with three or four active. Memory is 500ksamples, shared between the four channels, which is more than adequate but not as large as some desktop scopes.

The waveform update rate is up to 50,000 waveforms per second – again, more than adequate and this rivals many desktop scopes but a few high-end units will do more. As with the memory depth, it would be a rare situation where you actually need a higher rate than this. Basically you would only need it if you were searching for very occasional runts or other malformed pulses.

Acquisition and triggering

Like many modern scopes, in addition to the sample, average and peak-detect acquisition modes, this one offers a high-resolution mode which provides some of the noise-removal properties of averaging mode but can be used with non-repetitive signals. It gives a much cleaner-looking result in many cases so it's a welcome feature.

One thing we've noticed in using this scope is that its triggering system seems exceptionally accurate and stable.

When using the normal level-based triggering, the trace always seems to cross the intersection of the timebase origin and trigger level perfectly. The basic trigger modes available are Edge, Glitch (positive/negative/both, min/max) and Pulse Width (positive/negative, shorter/longer/inside/outside width).

Measurements and other features

The RTH1004 can display up to four measurements in the upper-left corner of the screen. If showing more than two, the font shrinks so there's enough space.

Pretty much all the normal measurements are available, eg, frequency, rise time, fall time, pulse width, duty cycle, average, RMS, peak and overshoot. It can also display power readings such as apparent power and power factor. These measurements require one channel to read the voltage and another the current (via a clamp probe or an external shunt).

"MATH" modes are fairly basic and include addition, subtraction, multiplication, absolute value and square. An XY plotting mode is also available.

The RTH1004 also has the ability to operate as a data logger and to store and review trace history (with the segmented memory option). Plus it has a number of other features that we won't go into in detail including mask testing (with beep on failure) and vertical/horizontal cursors.

One feature which is missing from the RTH1004 is a spectrum analysis option. However, in our experience, this is not terribly useful on most scopes – you're generally better off with a separate spectrum analyser if you need this feature.

Also, it lacks "probe sensing", so you have to configure each channel for the correct probe attenuation setting. This is understandable given the isolated BNC sockets used and since the supplied probes are fixed at 10:1 (and likely you will be using these often), it isn't a huge hassle.

Display and user interface

The 800 x 480 pixel 7-inch TFT display is bright and offers high contrast and a good viewing angle. It provides 10 horizontal divisions and 8 vertical. There's an option for a high-contrast colour scheme which makes it easier to view in direct sunlight.

The touch-screen interface is far from a gimmick. You don't have to use it; all functions can be accessed via the push-buttons and wheel and you can even turn off the touch function if you find you're accidentally activating it. But many functions are much easier (and more intuitive) when accessed via the touch-screen, especially selecting from drop-down lists and navigating through menus.

The arrangement of the front panel buttons is a little different than a traditional desktop scope, so it took us a while to figure out which buttons activated some functions.

But overall, the RTH1004 is quite easy and simple to use once you have done so. The buttons are large which allows operation even when wearing gloves.

Like pretty much all modern scopes, there is a "boot-up" time between switching the unit on and being able to use it but it's relatively short – just a few seconds. Switch-off is pretty fast and takes about one second.

And it does not have a fan, which is a pleasant change from many scopes with quite obtrusive fans.

Other options

The scope we're reviewing is a four-channel model and this is the one we would prefer to use in a lab environment where two channels often just aren't enough. Having said that, the two-channel model (RTH1002) does have one advantage besides a slightly lower price in that it replaces the two missing channels with a multimeter.

The four-channel model still has a multimeter mode which works with any combination of the inputs however it will only read voltages and only with a three digit read-out. Also you would probably want to use it with a BNC-to-alligator-clip cable.

But if you buy the two-channel model, you get two standard insulated banana sockets to plug standard multimeter probes into and a four-digit readout. While it can't measure current without an external current clamp or shunt, it does add resistance (up to 100MΩ), diode test, continuity, frequency and capacitance (up to 10,000μF) modes, plus the ability to measure temperature using a platinum RTD.

Accuracy is also improved compared to the scope-based DVM with a basic voltage accuracy of 0.05%.

While you have to choose between the two and four-channel models initially, everything else can be upgraded later: you can increase the bandwidth, add the logic analyser (eight channels, 250MHz, 125ksample memory), add serial triggering and decoding (I^2C, SPI, RS-232/422/485), add advanced triggering modes (TV, runt, interval, etc) and add Wi-Fi or LAN remote control.

Size, weight, battery, accessories etc.

Battery life is stated as four hours and our use gives us no reason to doubt that.

The scope weighs 2.4kg and while it isn't difficult to carry around, the average person would probably be quite fatigued if they had to carry it for long periods. Luckily it incorporates a fold-out stand and is quite comfortable to use on a bench top or other flat surface.

In fact, compared to a standard desktop scope it uses up about half the bench space, being narrower and lacking the front-facing input sockets. Its overall dimensions are 200mm wide, 300mm tall and 74mm deep.

The DC barrel charging socket is at lower left, hidden under a flap (to keep moisture and dust out) and it charges in a couple of hours using the supplied mains "brick". When you plug the charger in, the power button lights up blue and it changes to yellow once the battery is fully charged, so you can tell at a glance.

Also hidden under a flap, at the right-hand side, is the logic interface socket, USB host and device ports and Ethernet (RJ-45) socket for remote control.

The scope is supplied with two or four 10:1 probes depending on the model you buy, as well as the charger/power supply, battery and soft handle which makes it easier to carry one-handed. The probes supplied are high-quality types but they are also quite large and chunky with insulated alligator ground clips on the end of quite long wires. They are good for probing low-frequency, high-voltage equipment but clumsy for hooking into a packed PCB.

To be fair, most scopes suffer from the same basic problem – the probes are based on decades-old designs and do not work well with modern electronics which involves much smaller components mounted closer together. And most SMDs have no legs or pins you can easily hook onto.

One very nice feature of these probes is that they are supplied with an insulated ground spring clip. This replaces the long ground wire and is necessary for probing high frequency signals (>10MHz say) if you want an accurate idea of the waveform shape. Most probes are supplied with uninsulated springs which are very frustrating to use as unless you are making connections to a set of pads designed to suit the probe, you have to worry about accidentally shorting nearby components to ground.

Quirks

One oddity we noticed is that when the timebase is set to less than 1ms/div and you freeze the display, it always shows multiple waveforms overlaid, even when persistence is tuned off. If you really need to capture a single waveform at a fast timebase you can use the single trigger mode; however we are in the habit of simply freezing the display using the Run/Stop button in Normal or Auto mode to examine a non-repetitive waveform more closely, so this is baffling behaviour.

By the way, there's no dedicated single trigger button (as is common on many scopes); you need to change the trigger mode to Single and then press the Run/Stop button to capture a waveform.

Conclusion and special offer

While this scope may not have a full complement of bells and whistles, as a test instrument goes, it's hard to think of any that are more practical and flexible. And given that you are effectively getting four built-in high-performance isolated differential probes along with a portable, high-bandwidth, high-resolution four-channel DSO, it's great value.

Rohde & Schwarz have two special offers for this product line which are valid until June 30, 2016:

Offer #1 ("Lab"): Buy any four-channel R&S Scope Rider model (starting from $5650 ex GST) and get these for free: Mixed signal analysis (RTH-B1), I^2C/SPI serial triggering and decoding (RTH-K1), UART/RS-232 serial triggering and decoding (RTH-K2) and Advanced triggering (RTH-K19).

Offer #2 ("Field"): Buy any two-channel R&S Scope Rider model (starting from $4710 ex GST) and get these for free: Wireless LAN (RTH-K200), Web interface remote control (RTH-K201), Hard shell protective carrying case (RTH-Z4), Car adapter (HA-Z302), Battery charger for Li-Ion Battery (HA-Z303), Replacement battery (HA-Z306), Extended set for RT-ZI10/RT-ZI11 (RT-ZA21).

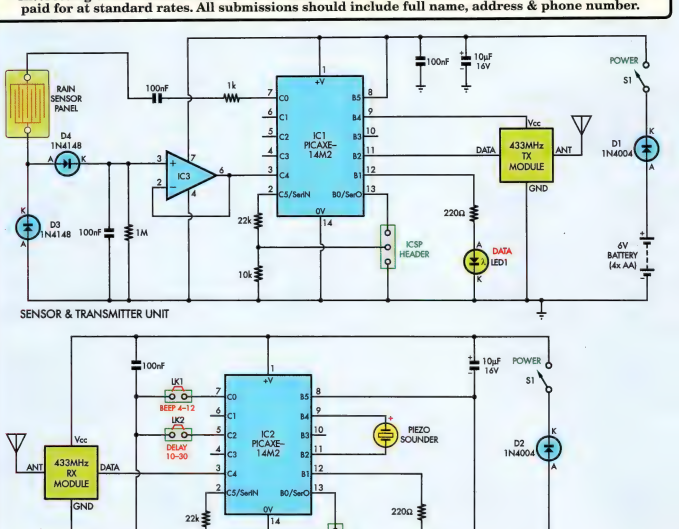
To make an enquiry or purchase, contact a Rohde & Schwarz reseller.

For Australia, these are Mektronics (call 1300 788 701 or email **sales@mektronics.com.au**) or Test and Measurement Australia (call (02) 4739 9523 or email **sjb@TandM.com.au**). Or for New Zealand, Nichecom (call (04) 232 3233 or visit **www.nichecom.co.nz**).

Alternatively, you can contact Rohde & Schwarz Australia directly on (02) 8874 5100 or e-mail **Sales.Australia@rohde-schwarz.com**

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



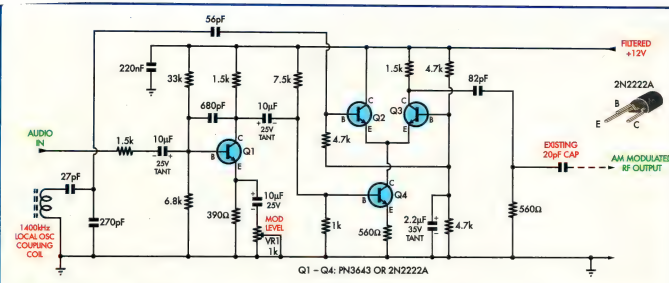
Wireless rain alarm

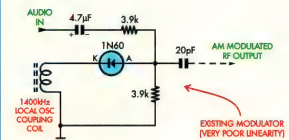
This rain alarm can be used on wash days to detect rain falling on a sensor unit located near your clothes line. It uses an AC voltage across a pair of closely-spaced PCB tracks to detect moisture. The resistance between the strips drops considerably when wet, triggering the alarm. The applied 20kHz AC voltage avoids electrolytic corrosion on the copper strips, as would be the case with a DC voltage or current.

The sensor unit is based on a PICAXE14M2 (IC1) and a ZW3100 433MHz transmitter module. The 20kHz signal is generated using the BASIC "pwmout" command and appears at pin 7 of IC1 (output C0). This is coupled to the rain sensor via a 1kΩ current-limiting resistor and 100nF AC-coupling capacitor. The output of the sensor is rectified by D3 and D4, filtered by a 100nF capacitor and buffered by op amp IC3, then applied to analog input pin 3 of IC1.

The software monitors this voltage via an internal analog-to-digital converter (ADC) and when the voltage exceeds 2V the alarm sequence is triggered. Alarm calls are transmitted by turning on output pin 9 on IC1, powering the TX module's V_{CC} pin, while output pin 11 on IC1 sends an 8-byte alarm code to the TX module's DATA pin using the "rfout" command. LED1 flashes once when the unit is turned on and each time an alarm code is sent.

The receiver unit is based on a





Improved amplitude modulator

Audiovox converters still turn up on eBay from time to time. These are basically FM tuners that plug in series with the antenna wire to an AM radio and put the received FM station, amplitude modulated, onto a 1400kHz (or thereabouts) carrier so the AM radio can receive it. They are useful additions to vintage cars or vintage radios so that you can receive FM stations on the original AM radio.

I fitted one to my Triumph TR4A but much to my dismay, the distortion was woeful. I opened the Audiovox converter up and discovered that their modulator was basically just a single 1N60 diode (see diagram). So I came up with a much better modulator circuit (shown above) and now it sounds much better.

The audio signal is applied to the base of Q1, a 2N2222A or equivalent. This acts as a common-emitter amplifier with a 680pF Miller capacitor to limit its bandwidth. VR1 controls the amount of emitter resistor bypassing and thus the gain.

NPN transistors Q2, Q3 & Q4 form the modulator. Q3's base is biased to half supply by two 4.7kΩ resistors with the voltage stabilised by a 2.2µF bypass capacitor. Q2's base is biased to the same DC voltage via another 4.7kΩ resistor however the 1400kHz local oscillator is also coupled to its base via a 56pF capacitor, modulating its base voltage and thus collector current.

Since Q2 & Q3 have their emitters tied together and together supply current to Q4, if the total current remains the same, when Q2 provides more current (due to a higher base voltage), Q3 provides less, thus reducing the voltage across its 1.5kΩ collector resistor and increasing Q3's collector voltage. As a result, the 1400kHz signal appears at Q3's collector where it's coupled to the AM radio via the pre-existing 20pF capacitor.

The total current through Q2 & Q3 is determined by how hard Q4 is switched on, which in turn depends on the audio signal applied to its base. So as the audio signal voltage rises, Q4 sinks more current and Q2 & Q3 in turn must supply more, thus increasing the amplitude of the 1400kHz output signal.

Similarly, when the audio signal voltage falls, Q2 & Q3 supply less current and so the 1400kHz output signal amplitude drops. Thus, the audio signal modulates the local oscillator gain.

Hugo Holden,
Minyama, Qld. ($60)

PICAXE14M2 (IC2) and the ZW3102 receiver module. Transmitted codes are picked up by the RX wireless module and drive input pin 3 on IC2. The software uses the "rfin" command, then checks if the alarm code is correct before triggering the alarm sequence. Alarm LED2 flashes once when the unit is first turned on and once a second for an alarm.

LK1 determines if the alarm sound has four or 12 beeps, while LK2 selects a delay of 10s or 30s between alarm sounds. Internal pull-up resistors are enabled at pins 5 & 7 by the software. The piezo transducer is driven in bridge mode, ie, with signals of opposite phase from pins 9 & 11, to provide sufficient volume.

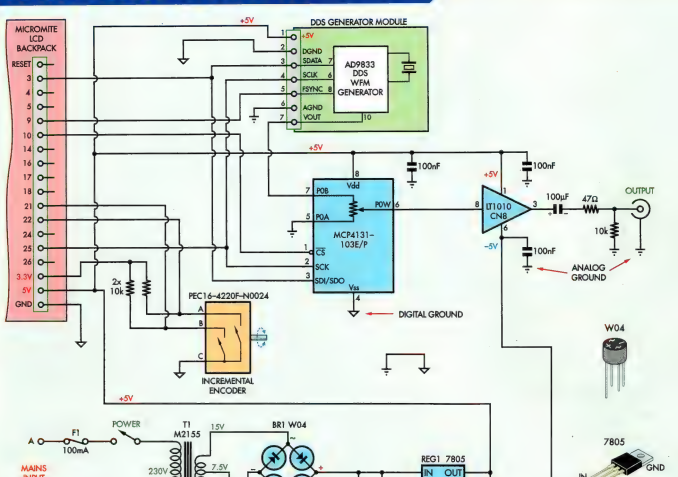
The transmitter and receiver modules require an antenna in the form of a length of plastic or enamel-coated wire 170mm long. This antenna wire can remain straight or be coiled into a spiral. Rain sensor panels can be made using Veroboard or etched on a PCB and the circuit shows the general layout with two interlocking grids. The prototype sensor uses a total of 20 strips and is 55mm square.

Sensor panels with plain copper strips will require regular cleaning while PCB-based strips can be plated with tin, nickel or gold for minimal cleaning.

The sensor unit and alarm unit are both powered by 6V batteries; each has a power switch and a series diode to reduce the voltage to just over 5V, while also providing reverse battery protection.

The same code is used for both IC1 and IC2. The software checks the voltage level on pin 8 and runs the transmitter code if the pin is high and the receiver code if the pin is low. The chips can be programmed using the ICSP headers provided with a PICAXE-compatible USB cable. The **rain_alarm14m2.bas** software can be downloaded from the SILICON CHIP website (free for subscribers).

Ian Robertson,
Engadine, NSW. ($70)



12.5MHz touch-screen function generator

This function generator can produce a sine, triangle or square wave output from 0.1Hz to 12.5MHz in 0.1Hz increments and the output amplitude is adjustable. It also provides a frequency sweep facility. As well as the touch screen interface, provided by a Micromite LCD BackPack, a rotary encoder knob can be used to change the frequency or amplitude.

The LCD BackPack provides overall control while a small AD9833-based DDS module (available on eBay) generates the signal. An MCP-4131 10kΩ digital potentiometer provides digitally controlled attenuation and an LT1010 buffers the output to source or sink up to 150mA.

Besides a few resistors and capacitors, the only other components are the rotary encoder for the knob interface and a linearly regulated ±5V power supply derived from a small 15V centre-tapped mains transformer.

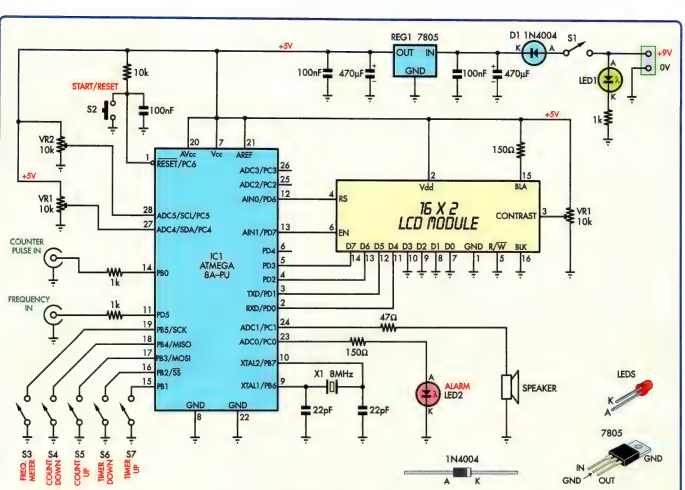
The BASIC software on the BackPack presents the touch-screen user interface and based on the user input, sends SPI serial commands to the DDS generator module using pins 3 (data), 25 (clock) and 9 (frame sync/slave select). Both the DDS generator and BackPack module are powered from the +5V rail.

The BackPack also controls the digital pot using SPI with the same data and clock lines but this time using its pin 10 output as the chip select line.

Depending on the command sent to the MCP4131, the "wiper" pin (pin 6) is connected somewhere along a resistor ladder between pins 5 & 7, via internal transistors. This has the same effect as rotating a potentiometer in controlling the attenuation between pins 7 & 6.

The LT1010 power buffer has a specified bandwidth up to 20MHz so has no problems handling the signal from the DDS, although high-frequency triangle and square waves may see a little rounding. Its total harmonic distortion figure is somewhere around 0.1-0.2%.

The LT1010 runs off the 10V split supply (+5V and -5V). Its output is AC-coupled via a 100µF electrolytic capacitor to remove the DC bias from



Combined timer, counter & frequency meter

This circuit provides an up/down timer, an up/down counter and a frequency meter in one package. It is based on an AVR ATmega8 and a 16x2 alphanumeric LCD. The timer and counter share an alarm system consisting of a speaker which can play a melody and a blinking alarm LED (LED2). Each function can be selected by operating its associated switch (S3-S7).

At power-up, S3-S7 should be off and VR2 and VR3 set to minimum. S1 can then be switched on to power the unit up. At this point, you use VR2 and VR3 to set the alarm to a specified value ranging from 1 to 1000 with VR2 or 10 to 10,000 with VR3. Using VR2, the count increments one by one, from 1 to 1000 (eg, 1, 2, 3, etc.). Within this range, it is better to use only VR2. Pot VR3 increments by 10 (eg, 10, 20, 30, etc), from 10 to 10,000.

For values beyond 1000, rotate VR3 first and then VR2 for the remainder of your chosen value. The display will show the sum of VR2 and VR3. Thus with both pots set to minimum, the display will show zero, and with both pots set to maximum, the screen will display 11000. Both the up/down timer and up/down counter times are set using these pots.

Once the timer has been set with VR2 and VR3, turn on switch S7 and press S2 to start the count-up timer. The upper line of the display shows the counter and the lower line shows the target value. As soon as the timer reaches the target, the display indicates "Time Is Over" and a short melody is played for three seconds followed by the blinking of alarm LED2. Once the melody is finished, the display shows that the program has ended but LED2 will flash until the reset button is pressed.

You can pause the timer by turning timer switch S7 off. If S7 is turned on again, the timing will continue. A similar procedure is used for the count-down timer except S6 is used to initiate it.

The up/down counter works the same as the timer except instead of counting seconds, it counts pulses at the PB0 input of IC1 (pin 14). The signal source should be a square wave or pulse train with an amplitude

continued on page 100

the DDS, along with a 47Ω resistor to protect against short circuits and isolate any load capacitance from the output of the LT1010.

The power supply incorporates a 100mA mains fuse and mains switch. The output of the 15V centre-tapped transformer is full-wave rectified by BR1, charging different-sized capacitors for the positive and negative rail, as the positive rail is more heavily loaded.

Standard 7805/7905 linear regulators are used with 100nF input bypass capacitors and 22µF output filter capacitors.

The BASIC source code and user manual PDF are available as a download from the SILICON CHIP website.

Dan Amos,
Macquarie Fields, NSW. ($70)

Vintage Radio

By Terry Gray

The AWA 461 MA clock radio & the Heathkit RF signal generator

Restoring a vintage radio can be time-consuming, particularly if you also have to fix the gear that's meant to help fix the radio. In this case, I started out restoring an AWA 461 MA clock radio and ended up also repairing a Heathkit RF signal generator and a Racal frequency counter.

IT STARTED out innocently enough when my thoughtful, ever-loving eldest son presented me with an old radio "to repair". "Happy Birthday Dad".

I had a small radio and TV repair business when I was a lad so it was not unreasonable for him to imagine that I would be interested in spending some of my retirement bringing an old radio back from the dead. After all, I still played around with electronics and had a scope, a soldering iron and other parts on hand.

I had even designed a few bits of test gear for our local BMW dealer over the last few years, so how hard could it be?

My son bought the radio from a second-hand shop in Sydney. It was an AWA 461 MA superheterodyne clock radio in a burgundy plastic case that really looked the worse for wear. It was missing several knobs and the scratched tuning dial featured all the popular NSW stations, so it wasn't much use here in Victoria.

Nevertheless, a smile and a hug sealed the deal. "You'll have fun with that" were my son's parting words.

If I had known then what I know now, I would have fed the thing into the nearest compactor but that's not the way families operate is it? No; I now had an obligation, an absolute duty, to make my son proud of his gift – and of his Dad who will surely make this thing look and work like new. Gulp!

It was some months later when I finally got around to looking at it. Unfortunately, if the outside looked bad, then the inside looked even worse. Someone had obviously been playing with the clock mechanism, as it was missing many pieces and may even have overheated at one stage. All four valves were present at least but to this crotchety old gift recipient, this radio was an absolute waste of time. In short, it was a veritable write-off.

A few days later, I found myself complaining along those lines to my neighbour and friend John who lives across the road. John is a vintage radio enthusiast who has years of experience in these matters, hundreds of radios and no sympathy for whingers like me. "Just fix the !@#$% thing", he said, "here, use this for parts".

He then presented me with a cream version of the exact same model radio from his vast collection. Wow! Such generosity. I instantly had a few more knobs, another clock mechanism, and a "Radiola" label for the front of my burgundy cabinet. This was progress, especially as the gifts kept coming. John then handed me a kit of replacement capacitors. "Change the capacitors first" he said. "It's always the capacitors". Thanks John.

Returning home suitably chastised but with renewed enthusiasm, I found a service manual for the AWA 461 MA radio at the impressive **www.kevinchant.com** website. Here was a complete schematic diagram (with voltages), a parts list and alignment information. Great!

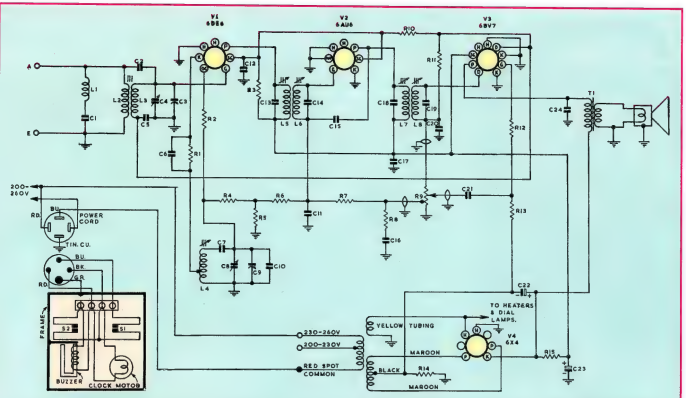


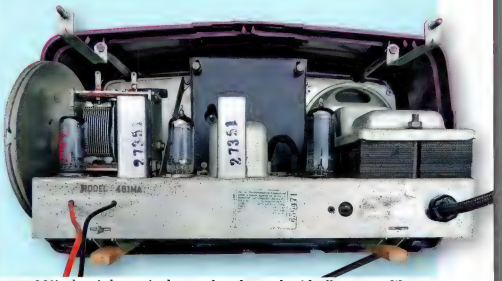
Fig.1: the circuit of the AWA 461 MA clock radio. It's a fairly conventional 4-valve superhet set with a 6BE6 converter, a 6AU6 IF amplifier, a 6BV7 detector/AGC/audio output stage and a 6X4 rectifier. It also incorporates an electric clock with an alarm to switch on the radio at the set time. (Circuit courtesy www.kevinchant.com).

I swapped out the electrolytic capacitors in both radios, as well as some of the black non-polarised capacitors that had visibly cracked open. Some of the remaining capacitors looked OK to me and seemed to react appropriately when connected to my multimeter. However, I couldn't be sure if their values had drifted, so I logged on to eBay and purchased a capacitor tester. It wasn't very expensive but I was confident that it would prove useful. The buying spree had begun.

With both radios now displaying some sort of life, I checked that the voltages at various points on the circuits were reasonable. Some valves were faulty but I had enough in my spare parts drawers to swap them around so that I ended up with reliable sets.

The next obvious problem was reception. A few faint and garbled stations appeared in the background when I powered the radios on but as I live in the Dandenong ranges opposite some powerful phone towers and in a house full of switchmode LED lighting, what chance did I have? Even stringing an antenna wire outside and ensuring I had a good ground wasn't enough to ensure good reception.

Both radios performed similarly so it appeared that lack of signal was the only problem. Indeed, even my car radio struggles at home until I drive some distance away. Perhaps if I used an RF generator, I could simulate some stations and tweak the alignment to improve performance.



The 461 MA's chassis layout is clean and uncluttered, with all parts readily accessible. The clock mechanism is in the centre, next to the loudspeaker, and is fitted with a dust cover.

The Heathkit generator

It turned out that another friend (Ron) had an old Heathkit RF signal generator with a handy modulation option. You probably recognise the Heathkit name. From 1955 to about 1990, they manufactured a big range of electronic kits, including radios and test equipment. It was possible to buy them fully assembled for a few dollars extra but the vast majority were sold in kit form to be assembled by cus-

This Heathkit IG-102S RF signal generator was lent to me but it soon failed when I attempted to use it.

tomers whose skill level could best be described as "varied". While some obviously didn't know which end to hold the soldering iron, others did a very professional job indeed and I was really hoping that Ron's unit came from the latter group.

This Heathkit RF signal generator was sold from 1963 to 1977 and the IG-102S "S" model would have been developed towards the end of that period. What I didn't know then (but do now) is that the "S" indicates that it is a Berkley Physics Lab version of the instrument. It came with extra RF output connectors which provided a high-level direct output RF option and, according to a YouTube video, is not suitable for radio alignment due to the high RF levels radiated from the extra connectors.

That seemed to be a big call to me. It would surely be a simple matter to disconnect the high-output connectors inside the unit if stray radiation proved to be a problem.

While I was blissfully unaware of all this at the time, so was Ron. Apparently, he had never used this instrument and it had been given to him when he helped clean out someone's warehouse. From then on, it just sat unused in his shed, so he was happy to lend it to me. I so wish he hadn't!

Ron's RF generator came with a frozen band-switch and a power lead with a missing plug. It also had old microphone output connectors on the front that are all but useless these days and so, with Ron's permission, I changed these connectors to the more common BNC type. I then fitted a new mains plug, lubricated the band-switch so that it rotated and powered the beast on.

Everything seemed to work OK. The indicator light on the front of the instrument came on with what seemed like normal brightness and, with my radios whistling away in the background, I could easily tell that the unit was working. I played around with it for a while and eventually felt confident that it could provide the signals I needed for my alignments.

Another clock radio

It was about then that I came across another Burgundy AWA 461 MA clock radio (just like the one my son gave me), this time on eBay. Happily, this one had all its knobs and it looked to be in very nice condition indeed with few, if any, scratches.

I accept that this is getting a bit like the story about grandpa's axe having had its handle and head changed several times, with the claim that it was still grandpa's axe. However, there was no way that I could get the cabinet on the set my son gave me to look as good as the one on eBay, so I entered the bidding war. It ended up being a tad expensive and it had to be picked up way across the other side of town but I was committed now and was obviously becoming more so as time went by.

When I went to collect my new radio, I discovered that it wasn't the only radio that the seller had. Like John, here was another enthusiastic collector of vintage radios who proudly showed me his assorted collection of different makes and models. During the tour, I reflected that while he had this amazing gallery of radios, I now had a sum total of just three. And mine were all the same!

My latest purchase proved to be as good a radio as advertised. The case had very few marks and its dial featured Victorian stations. The seller also kindly showed me how he polished his plastic cases with very fine grit emery paper and plastic polish. He even gave me some to take with me and I was beginning to think that it pays to look impoverished; people give you stuff!

Back home, I pulled all three radios apart and started with the clock mechanisms. Sadly, out of the three radios, none of the clocks worked reliably, so I had to swap assorted shafts and gears around in order to get a single working unit. This clock mechanism, by the way, incorporates the power switch, an alarm function and a devilishly-designed "snooze" function that is entirely mechanical.

The best knobs were then selected and popped into my ultrasonic bath to be cleaned up. They are far from perfect but are good enough and, at least, I now had a full set.

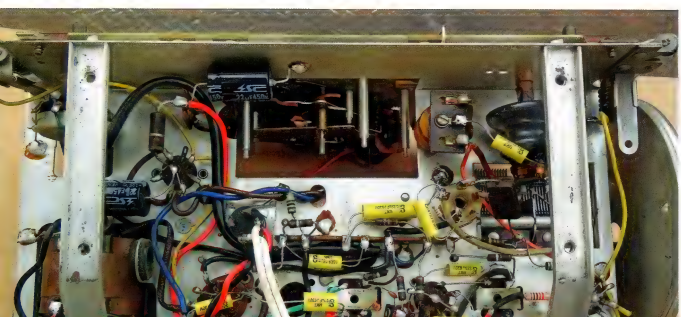
I then asked John if he had a frequency counter I could borrow so that I could get the alignment as accurate as possible. I wasn't worried about having the IF off by a few Hertz but I certainly wanted the radio stations to line up to the markings on the dial. Some radio station frequencies have shifted since this radio was made, of course, and some have even disappeared all together, but I planned to get everything as close as possible by following the prescribed alignment procedure.

Anyway, John presented me with an old Racal 9835 Universal Counter. He thought it worked OK but typically, when I turned it on, it didn't.

I opened it up and found that the AC/DC input selector switch on the front panel had fallen apart internally. As a result, I bought a standard slide switch to replace it but its plastic lever needed a lot of filing to make it fit correctly in the case opening. The frequency counter worked after that but I then noticed that the least significant Nixie tube wasn't lighting up.

Blast! I can't be sure but I'm confident that it would not have been working when John first gave it to me. And so, rather than have something else go wrong, I put the Racal aside and ordered a cheap but cheerful frequency counter from Asia (more money out the door). I also ordered some alignment tools online (no knitting needles for me) and when they finally arrived, I felt that I finally had everything I needed to align my radios.

The instructions provided with the Heathkit RF signal generator advised allowing some 15 minutes or so for both the radio and generator to warm up and "stabilise" before commencing



The black non-polarised capacitors in the AWA 461 MA's chassis were eventually all replaced with modern high-voltage equivalents, as were all the electrolytics. In addition, the twin-core mains flex shown here was later replaced with a 3-core flex so that the chassis could be earthed.

lignment. And so I dutifully switched verything on, set the generator to modulate" mode, and left the room. didn't know it then, but my problems vere about to start in earnest.

What's that smell?

Twenty minutes or so later when I eturned full of tea, biscuits and enhusiasm, I found my makeshift workhop awash with foul-smelling smoke. The Heathkit generator was hot and mouldering on the inside but luckily ts metal case ensured that the internal ire hadn't spread.

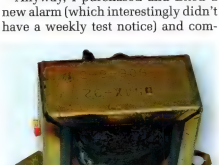
Suddenly, the lack of a mains fuse n the device, plus the absence of any ound from our smoke detector in he passageway outside, seemed very cary indeed. So why had the generator gone up in smoke? And why had the smoke detector not sounded an alarm?

I thought I'd better tackle the smoke detector first. It was only four years old and it still gave out regular red flashes, ndicating (you could say "pretending") that it was working. Replacing he fairly fresh battery and pushing the "test" button did absolutely nothing, so I had a dead smoke alarm. There was nothing for it but to buy and fit a new one.

I confess that having taken the alarm down from the ceiling, I noticed (perhaps for the first time) its now obvious "Test Weekly" notice. Prior to this incident, I was mildly proud of my conscientious annual smoke alarm battery swapping but let me ask you all this: who actually tests their smoke alarm weekly? Certainly not this little black duck.

I'm actually rather wary of the thing to be honest. Its 85dB horn is so loud that it would set my tinnitus-troubled ears ringing for much more than the prescribed week.

Anyway, I purchased and fitted a new alarm (which interestingly didn't have a weekly test notice) and committed myself to test it every now and again – with ear muffs on.



The power transformer inside the Heathkit RF generator ended up a charred mess because someone had modified the power supply.

Back to the generator

Once the new smoke alarm had been installed, I opened up the Heathkit generator to find the mains transformer a charred mess. It was well and truly cooked and a look at the schematic diagram indicated that this American-designed kit had a 110VAC transformer! However, this unit had obviously found its way to Australia and even though it wasn't fitted with an Australian mains plug, it did have a good-quality 3-core mains cord.

A closer look at what was left of the transformer showed that it had two primary windings wired in series, so I was confident that this unit was indeed designed to handle 230VAC. But why had it failed so dramatically?

At first I told Ron that his generator had fallen off the perch and that was it. However, as I had borrowed the thing, guilt drove me to try to return it in working order, regardless of what would be involved in fixing it.

To prove the lunacy of my quest to bring this thing back to life, it is worth noting that the price of an IG-102 kit from Heathkit in 1976 was the princely sum of US$44.95.

With Christmas fast approaching

This close-up view shows the clock mechanism before restoration. Parts had to be scrounged from three different chassis in order to repair it.

and many requests from my family for gift ideas for the man who is impossible to buy for, I set my heart on a Siglent SDG 1010 arbitrary function generator. The more I looked at this product, the more impressed I was. This thing could do everything I needed in the signal generation stakes for the rest of my time on earth.

Santa duly arrived as expected and it was mine. As it is a digital device, I simply select the type of waveform I want, enter in the desired frequency and the output level, set the modulation and "voila", there it is. There's no need for a frequency counter now but should I need one, even that capability is built in.

The Heathkit's mains transformer obviously needed replacing so I contacted Southern Electronic Services in Dandenong South and gave them the specifications: one secondary at 120VAC 20mA and another at 6.3VAC 1.2A (for the valve filaments and power indicator lamp). They did a great job at a reasonable price and a few days later I had my replacement transformer. It was slightly larger than the original but a new mounting hole was drilled and it fitted in the case just fine.

I then pulled out the circuit schematic and had a close look at the Heathkit-designed power supply section. It showed a single solitary diode rectifier. Half wave rectification would you believe? Wow; very basic stuff indeed.

I found myself wondering why Heathkit hadn't added a few more diodes for a full-wave rectified supply. The decision was probably due to cost but I wasn't all that impressed.

Imagine my surprise then when I looked at the actual power supply components inside the generator and found that someone had, like me, decided that the power supply wasn't all that great and had built their own. However, in place of the original single diode design, he'd used a voltage doubler! What the . . .!

So the power supply, at least, was nowhere near the original design. It had all looked reasonably well built when I first looked inside but I now had no idea if anything else had been changed, was the right value, or was even the right way around!

I connected my multimeter to the output of this redesigned power supply and instead of the specified 130V, it read 300V! As the valves warmed up and drew some current, this voltage fell to 220V or so but that was still way over what it was supposed to be!

But that wasn't the only surprise. When I switched the "modulation" function on, the voltage dropped to 50V! So what was going on here?

The cause was easy to find. The modulation select switch had a 500nF capacitor off one leg that was rated at 200V but it was now acting as a straight piece of wire. In other words, it was a dead short which went some way towards explaining why the transformer had burnt out. Replacing it with a new 600V-rated component solved that particular problem.

According to the documentation I found on-line, the original power supply featured a dual 20µF 200V capacitor that was fitted inside a single tubular case. I found a picture of one at http://www.wb0smx.net/?p=1910 but sourcing the exact same unit would probably now be impossible.

After some thought, I decided that the easiest thing to do would be to rewire the power supply so that it was close to its original design. The electrolytic capacitors used in the doubler were marked 24µF but measured 29µF on my capacitance meter. That seemed OK, so I used two of them with a new 2.2kΩ 1W resistor between them as the original schematic specified.

I did make one change though. I couldn't help myself and replaced the single diode with a bridge rectifier. While this would give a slightly higher voltage than a half-wave rectifier, it would also have far less ripple, which in an instrument such as this seemed desirable.

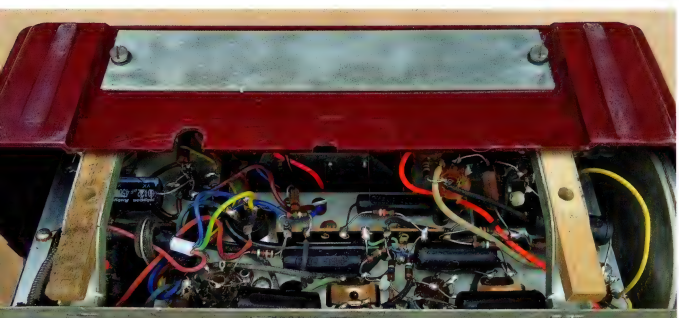
Low RF output

With the nightmare realisation that the unit might have been modified fairly heavily in other areas, I then explored further. The unit featured a "modulation out" port that was meant to supply an audio signal at around 400Hz. This was working – but at 180Hz!

It didn't take long to discover that the 0.01µF oscillator capacitor (C16) was way off tolerance and replacing that brought the frequency up to a more acceptable 330Hz. However, the RF output level was miserably low, so much so that none of my counters would register a signal unless the output was set to the absolute maximum.

A closer look around the pentode output stage of the 6AN8 revealed some clues. First, the cathode resistor had been changed to 470Ω instead of the 39Ω value specified on the schematic. This 470Ω resistor was a 1W device and it had been getting hot! Plate drive resistor R11 had also been getting hot and was now effectively open circuit, so I replaced it with a new 680Ω unit.

The RF signal strength was still negligible at the BNC connector so I checked the input signal at the grid of the 6AN8 pentode. It looked OK as did the nice 40V peak-to-peak signal at the anode. However, this healthy signal was being heavily attenuated by



his chassis had been fitted with a new mains cord but had yet to have its black non-polarised capacitors replaced when his photo was taken. All three radios worked after restoration but only one had a working clock.

ne time it got to the output connector.

All that sat between the plate of the entode and the output connector was coupling capacitor and a few resistors. I replaced the capacitor first but made no difference. Unfortunately nough, I was really flying blind and I eally needed to know what the output ignal strength should be.

I downloaded several copies of the ser and construction manuals but ypically, while the index of every single one told me that the specifications were on page 32, that was always the ne page that was missing. Just that ne wretched page – give me a break.

then turned to YouTube and took a ook at some of the world's most boring ideos of guys describing the minutiae f this particular RF generator. And as ear as I could tell from these mindnumbing monologues, the output is ust 0.1V into a 50-ohm load.

Google also subsequently led me to couple of comments about the low utput of these generators and how ome owners had done away with the alves altogether and installed FETs! The logic here was that the 6AN8 was truggling to provide a decent signal nto a 50-ohm load. Others had simply replaced 47Ω attenuation resistors R14 and R16 with 220Ω resistors to ncrease the output.

This was considered valid since the generator didn't have a calibrated output as such. In addition, increasing the value of these resistors to lift the output level would also improve the signal-to-noise ratio.

So what did I do? I took the easy way out and replaced the 47Ω resistors with 220Ω resistors as suggested and, at last, finally had a working generator. It now gave me 400mV peak-to-peak at maximum output and while it's nothing like the 20V peak-to-peak (into a 50-ohm load) that I get from my Siglent, at least it's usable.

In retrospect, it's just possible that the low output problem was the very reason that the power supply was so heavily modified in the first place. It certainly allowed the unit to work when I first turned it on but, of course, it didn't last long.

I won't tell you how much this all cost in time and money because Ron may read it one day and say "you shouldn't have" and I will be forced to punch him on the nose.

Remember the radios?

With the Heathkit generator all done and dusted, I finally got back to looking at the AWA 461 MA clock-radios. Remember them?

From this point on, it was all something of an anti-climax because, in each case, the alignment procedure went along fairly smoothly. I could select 455kHz exactly with my Siglent generator and, with 400Hz of modulation, could easily tweak the IF cores for maximum output on my scope. The front-end coils and capacitors were then adjusted for maximum antenna sensitivity and to align the stations with the dial.

The three radios varied in their performance characteristics, so I simply picked the best-performing chassis for my final radio. I then straightened the large dial pulley to ensure that it was exactly square with the tuning shaft (necessary to stop the tuning cord leaping off the pulley every now and again) and shortened the dial cord a tad to increase the cord tension and make the tuning as reliable as possible.

With the main radio finally assembled and looking the part, I turned it on. The reception was still awful for the reasons I had described earlier but it was particularly bad now because, given the festive season, I had covered our property at her majesty's insistence with Christmas lights; you know, the ones that flash on and off all the time and generate interference.

Not much of the original radio that my son gave me was used in this set; only a knob and a clock shaft or two. But he'll never know . . . as long as you don't tell him! SC

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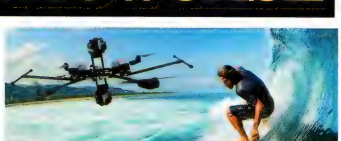

Drone Volt's Janus 350 Ten-Camera 3D Virtual Reality Platform

DRONE VOLT, the French leader in professional drones, is revolutionising the world of photography and cinematography with the JANUS 360 , intended for 360° Virtual Reality content production.

Virtual reality has a tremendous future and points to a growing need for 3D content filmed in 360° for cinematography, tourism, advertising, sports and sports training, gaming, design and architecture, construction, real estate and many other industries.

To meet the needs of this strategic market, the R&D division of DRONE VOLT has integrated the best of its technologies to develop the JANUS 360 by DRONE VOLT. It offers 15 minutes of flight time and a double stabilised head, can capture spectacular aerial images used (after video processing) in virtual reality playback systems, goggles or helmet.

A genuine flying camera, the JANUS 360 is dedicated to producing video content for virtual reality, equipped with **ten** 4K cameras spread over two heads is for taking pictures and videos that once assembled and processed provide an immersive 3D experience for virtual tours and 360° videos.

Contact:
Drone Volt
14, Rue de la Perdrix, Paris Nord 2, France
Tel: 0011 331 8089 4444
Web: www.dronevolt.com

Icom shows IP Advanced Radio System at CeBIT

Icom Australia exhibited at CeBIT 2016, showcasing the IP Advanced Radio System which is a unique, innovative and versatile IP two way radio communications system that is designed to work over an existing wireless LAN and IP networks.

The system provides licence free, yet secure communications, making this system cost effective and easy to use.

Along with the IP system, they also demonstrated their traditional RF radios such as the IC-F1000 and the VEP-G3 gateway. The VE-PG3 is designed to enhance the communication coverage of a radio network and the convenience of radio usage by leveraging IP networking technology with ease of implementation.

Contact:
Icom Australia
Unit 1, 103 Garden Rd, Clayton Vic 3168
Tel: (03) 9549 7500
Web: www.icom.net.au

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Fingerprint scanner not recognising fingers

I recently built the Fingerprint Scanner Access Controller project from the November 2015 issue. I wanted to use it with a 12V DC relay to activate the manual open button of my roller door from outside the front driveway.

Right from the start things did not go smoothly. All the wiring went OK but trying to register any of my fingerprints took an eternity – at least half a dozen attempts per finger and I tried the middle and pointer fingers of each hand, all moistened as per instructions. When they did eventually register, not one of them would be recognised by the scanner and allow entry.

I then asked my wife to try with her fingers but we had the same problems. I re-read the article and changed the scan resolution to low and we had a little more success. This time it only took three attempts to register the fingerprints but still would not allow entry once registered, except once when it took a full one minute of finger pressing to accept my fingerprint. Hardly satisfactory at the best of times, less so if it's pouring with rain!

Have any others had problems with this project or have you posted any Notes and Errata to overcome these issues? All components are as per the article and the module/JST lead were from Little Bird. (P. C., Woodcroft, SA.)

● The Fingerprint Scanner prototype had none of these problems and nor did Altronics have problems with their prototype kit. Registering a fingerprint shouldn't take so many attempts.

The problem would appear to be with the fingerprint scanner itself. How long are the connecting wires between the fingerprint scanner module and the SILICON CHIP unit? Keep these wires as short as possible and away from any electrical interference or mains wiring.

Also check that the module screen is clean and that the internal blue LED lights when a finger is placed on the screen. The low resolution option for the scanner is not recommended and should not be required once the scanner is working properly.

Also, make sure the fingerprint scanner serial number is registered as described in the article first before attempting use of the scanner.

Induction Motor Speed Controller problem

I brought an Induction Motor Speed Controller kit from Jaycar and I have a few questions about it. I have an issue where the LED continuously flashes and the speed does not vary.

Other than that, the ramp works but only ramps up not down. Everything else works and it is running a 3-phase motor. (K.W., via email.)

● The fact that it only ramps up suggests that there is a problem with the DIP switch settings. Try running it in 3-phase external mode – see Fig.11 on page 76 of the May 2012 issue. (Note: the fault did turn out to be in the DIP switch setttings).

Logic level Mosfets for ultrasonic cleaner

I am attempting to build the Large Ultrasonic Cleaner by John Clarke (SILICON CHIP, August 2010). I am a mechanical engineer and I'm good at following instructions but not exactly an expert on electronic circuits.

I found that the RFP30N06LE 30A 60V Logic Level Mosfets described in the article are no longer available at Digi-Key or Mouser. Could you please suggest a part number for a replacement that will work? (B. S., via email).

● We can supply a pair of the equivalent logic-level Mosfets (IPP230N06L3) for $5 plus postage. You can purchase them from our website at **www.siliconchip.com.au/Shop/7/1863**

These Mosfets are also suitable for substitution into the Ultrasonic Anti-Fouling Unit (September & November 2010 issues), Barking Dog Blaster

Micromite Boat Computer Has No ETA Readout

A question for Geoff Graham: does the GPS Boat Computer featured in the April 2016 issue give an ETA for a destination? The Boat Computer has a clock and shows the current time and it also shows the current speed and distance to the current POI, so it should be able to calculate an ETA. It would ideally show both estimated travel time and ETA, as they are both useful.

I don't see any mention of ETA in the article so presumably this would require modifications to the BASIC source code. (Anonymous, via telephone.)

● Geoff Graham replies: the ETA is not shown as this is one of the things that sounds simple but is not that easy to do in practice. The calculation would be easy but there is not a convenient place to display the result — the POI part of the screen is already full. I suppose that we could have an extra display page but then we would need some way to switch to it.

Also there are so many other things that could be displayed (distance travelled, travel time, etc) that the Boat Computer would soon become a mess of options. I tried to design the Boat Computer so that it was intuitive for the user and in part that meant keeping it simple.

As it happens, I have a new version of the software that's just been released. It fixes a couple of niggles like an inconsistent pointer on the compass rose and also adds more POI "slots" but does not compromise the ease of use.

September & October 2012) and 40V
A Hybrid Switchmode/Linear Bench
upply project (May & June 2014). The
ritical Mosfet parameters are:
reakdown voltage: 60V
laximum DC current: 30A
eak current: 120A
ower dissipation: 36W
laximum on-resistance: 23mΩ @ 10V, 1mΩ @ 4.5V
laximum gate voltage: ±20V
nput capacitance: 1200pF
ate charge: 7nC
urn-on delay/rise time: 9ns/3ns
urn-off delay/fall time: 19ns/3ns

Finally, Altronics still have the kit or the Ultrasonic Cleaner – see www.altronics.com.au/p/k6021-high-power-ultrasonic-cleaner-kit/

Synchronous motor speed controller

I've been asked to make a controller or small synchronous motors, typically 0-30mA, 50Hz single-phase 230VAC, o start caps or switches. They are fairly ightly loaded through a gearbox.

After considering various methods, uch as driving a transformer with an udio amplifier, I'm wondering if a mpler, cheaper and less bulky option ight be something based on the Induction Motor Controller (April 2012) n a smaller scale using discrete IGBTs.

Would a capacitor-dropper be feasible for one or both of the low voltages ather than transformers? "15V hot" in our design has 0V in common with the rectified mains; the 3V3 supply doesn't.

One of the applications requires the motor to occasionally turn at twice normal speed for awhile (an hour or two). 100Hz can be generated but will the motor be able to keep up with the driving wave? Is slipping going to be a factor when increasing speed?

The motors I use with the Induction Motor Controller are also single-phase, connected across two of the three phases available, so I presume that for a dedicated usage only two of the three phases need to be made. (J. C., Auckland, NZ.)

- Check the turntable motor drive project in the May 2016 issue. It will drive turntables at 50Hz, 220VAC or 60Hz, 110VAC. The sinewave is generated by a micro and fed to pair of class-B amplifiers driving step-up transformer in bridge mode.

We don't have any facility for varying the speed over a really wide range. Note that if you double the drive frequency, the power delivered to the motor will be substantially reduced because of its inductance.

Also note that synchronous motors do not have trouble "keeping up with the driving wave". They are locked to the drive signal and there is no slip as there is with induction motors.

High-Current Adaptor Power Supply

I'm in the process of building the Isolated High-current Adaptor for Scopes and DMMs from the August 2012 issue and was wondering about a small change. Would it be possible (or advisable) to power the adaptor from a mains-derived power supply?

I only ask because I have a suitable transformer on hand and a suitable box which will take a 3-pin mains socket and has room to fit a power supply with a transformer, bridge rectifier and 7809 regulator.

I'd like to avoid problems with possible battery chemical leakage. Would there be any interaction detrimental to the operation of the device? (J. R., via email).

- Yes, you could power that circuit from a 9V DC supply derived from the mains. Just make sure the wiring provides sufficient insulation to maintain the isolation barrier. The battery was used mainly for convenience and flexibility, ie, allowing the device to be used to measure DC current and low-voltage AC as well as mains currents.

Remotely switching WiFi modem on & off

I would like to suggest a project. I wish to turn off my WiFi modem to re-

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Using A CDI On A Motorbike With Twin Coils

I found your website while researching building my own CDI for an old Suzuki GN400 street bike. I have tried many other CDI units on the GN400 but none really work well because the GN400 actually uses two trigger coils. One coil is for starting/idle and fires 10° BTDC and the other is fired 35° BTDC for engine speeds above 2500 RPM.

I once got the engine running on a Honda CH250 CDI, wired to the 35° coil. It was quite painful to start but it ran like a banshee once it was running!

I also have a CDI from a Suzuki SP500 which is DC-fired like the original CDI for the GN400. However, the SP500 CDI uses a 2-wire trigger coil, so I'm not sure I could connect a single-wire trigger coil to the 2-wire input on the SP500 CDI.

Is it possible to build a homemade CDI that would use both the trigger coils on the GN400? Both coils have one wire routed to the CDI because they each ground to the igniter coil plate on the engine case.

I'm thinking that using both trigger coils will give me a more desirable advance curve than using only one trigger coil. Or perhaps I could add in a tunable feature to the 35° coil input?

Any help is much appreciated. (A. V. H., via email.)

● Presumably the two trigger coils could be tied together using diodes (say 1N4004s) with the diode anodes to the coil and the cathodes (striped end) connected together to provide the trigger signal for the CDI. We suspect that the 10° coil would produce a higher signal level at low speed and whilst starting and the 35° advance trigger coil offers a suitable trigger voltage once the engine is running at speed.

This 35° advance trigger coil would trigger the CDI before the 10° trigger coil, thereby bypassing the 10° triggering. So presumably a standard CDI could be used but with the isolating diodes added to the two trigger coils.

Note that the 10° coil could use the opposite polarity for triggering compared to the 35° advance trigger coil. So the polarity of the diodes may need to be determined experimentally should one or both of the coils generate a negative trigger voltage. The diode for a negative trigger voltage would need to be reversed.

We published a CDI for motorcycles in May 2008 ("Replacement CDI Module For Small Petrol Motors"). A preview of this is available at www.siliconchip.com.au/Issue/2008/May/Replacement+CDI+Module+For+Small+Petrol+Motors

The SP500 CDI would appear to be directly unsuitable for the grounded trigger coil as used by the GN400. To use the SP500, you could possibly disconnect the ground connection on the trigger coils, tie these together and connect to one of the trigger inputs of the SP500 CDI. Then use the diode arrangement for the other trigger coil wires and connect to the second trigger coil input of the CDI.

Note that the trigger coil connection to the SP500 may need to be swapped, depending on the polarity required at the input. Note also the possibility that the trigger coil diodes may need to be reversed in polarity.

duce RF interference, save power and minimise the possibility of accidental/unauthorised WiFi use.

Switching off at the power point is useless if using a shared power board or a power point hidden away. I would like to remotely switch on/off the DC coming from the 9/12V power pack.

Can I please suggest a remote-controlled DC power switch, preferably re-using an existing TV remote controller. It would sit between the power pack and the modem. The unit could have a user-selected default to ON or OFF if mains power is interrupted.

Using a PIC would be great, giving the potential for a timer to be incorporated later. (T. R., via email).

● There are several ways to do this. You could use one channel from the 9-Channel Infrared Remote Control project from September 2015 (www.siliconchip.com.au/Issue/2015/September/Build+A+9-Channel+Infrared+Remote+Control).

Another option is the remote control used in the Barking Dog Blaster from the October 2012 issue. This used a commercial remote control from Kitstop (www.kitstop.com.au). See a preview at: www.siliconchip.com.au/Issue/2012/October/Wireless+Remote+Control+For+The+Barking+Dog+Blaster

Yet another option is to use a remote controlled mains switch to switch the plugpack on and off at the mains supply – eg, Jaycar Cat. MS-6142 or Altronics Cat. P8119.

Alternatively, Oatley electronics (www.oatleyelectronics.com.au) has a range of remote controls – see http://secure.oatleyelectronics.com/index.php?cPath=47

VK2828 GPS module connections for clock

I am assembling a "High Visibility 6-Digit LED GPS Clock" (Silicon Chip, December 2015 & January 2016) and have some questions about the necessary components to correctly mount a GPS module.

I have checked the specification sheet for the module fitted to the prototype shown in the magazine article. On page 45 of the December 2015 issue, it states that two resistors are added to CON2, one from +V to pull its enable pin high. In the specification sheet it only states "ENABLE/DISABLE: On / Off".

I am trying to understand the reasons for the prototype model's final design layout and this specification sheet information doesn't help me.

The GPS module that I have is a VK2828U7G5LF TTL GPS/GLONASS/GALILEO module with antenna and cable, as I purchased from the Silicon Chip On-line Shop.

I am surmising that because this module has an RS-232 capability (optional), I will need to add a 6.8kΩ resistor in series with the TX connection. What determines the best value to be used here? In the January 2016 article, it states that this resistance can be 4.7-10kΩ. How do I determine the correct value?

Does the "RX" connection need (like the prototype model) a 470Ω resistor, ie, when not in use this pin must be kept high for operation? The specification sheet states: "From Vcc connect a 470Ω resistor in series with a 3.2'

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CD-ROM Playback Adaptor Does Not Recognise Remote

I built the CD-ROM Playback Adaptor but when I go into the remote set-up mode, after a few seconds it shows "Press UNUSED". I tried several remote controls of TV, CD, SAT, etc, with RC5 encoding but none were recognised. The signal on pin 12 of the Atmel micro arrives properly but nothing happens and it always remains on this screen until reset.

Do you have any suggestions on this? (R. M., Lombardia, Italy.)

● An RC5 infrared transmitter should work if you follow these instructions. To assign the buttons for the remote control functions, press and hold switch S3, then toggle switch S1 for the orange LED to light and then toggle S1 again for the orange LED to turn off. You then follow the on-screen display instructions for pressing the remote control buttons.

zener diode to Ground. Then, connect the Rx input to the zener's cathode to pull the input high" (em408_ug.pdf – ver 1.4.1).

I am assuming that this module's V_{CC} pin can be connected directly to the V_{BAT} pin 6 on CON2. Likewise the GND connected directly to pin 5 on CON2. (N. A., Hamilton, Qld.)

● The GPS modules we supply are TTL types; no series resistors are required. The optional RS-232 capability has to be specified when the modules are ordered. All of our projects call for TTL signalling with GPS modules, hence this is what we supply.

The GPS clock has an on-board 10kΩ pull-up resistor for the RX pin. A lower value could be used but should not be necessary, We suggest using the 3.3V supply option with the VK2828U7G5. As stated in the data sheet, connect "EN" to the same pin as V_{CC} to enable the module. This module should not require any connections to V_{BAT} as it should have an on-board battery (and provides no connection for a battery-backed supply).

So to summarise: use a 3.3V supply, connect GND on the module to GND on the PCB, EN and V_{CC} on the module to V+ on the PCB, PPS on the module to 1PPS on the PCB and TX and RX as shown in the articles.

VK2828 GPS module queries

I purchased one of these modules from Silicon Chip. I have the module working with the Enable not connected and data being sent at 9600 bits/sec. There is a green LED flashing.

Does this indicate that the GPS is locked or just that it is sending data? Also should the enable line be connected to positive, ground or left disconnected? (R. S., Fig Tree Pocket, Qld.)

● There is a link to the module data sheet on the shop page of our website (in the item description). According to the data sheet, Enable should be pulled high for normal operation (ie, to V_{CC}).

It also says "Green light flashing means positioned" which we take to mean that if the light is flashing (at 1Hz, presumably), then the module has a position fix.

Electric Fence Controller Triac

I've built the Electric Fence Controller from the April 1999 issue. I couldn't get formers for E30 cores so I used E29 assemblies instead. As they're bigger, I had to redesign the PCB and stretch it.

I originally tried using a BT137X 600E Triac from Jaycar. However, when I fired it up, it lasted two pulses then died. The second one died even faster. It might be that the gate voltage is too high.

Anyhow, I substituted a C122E (500V) SCR left over from a long-abandoned 70s CDI project and it seems to work OK on the bench. Now the circuit is very similar to a CDI, so can it

Circuit Notebook: *Continued From Page 87*

between 3V and 5V peak. Use VR2 & VR3 to set the maximum number of pulses, then S5 or S4 to initiate up or down-counting respectively. As with the timer, when the counter reaches zero (in count down mode) or the target (in count up mode), the speaker will play a melody and alarm LED2 will flash. Switches S4 and S5 can be turned off during counting. Pulses received during this time will be ignored.

You may notice that when VR2 or VR3 is set to maximum, the counter reads about 2% higher than expected. This isn't harmful but if you want to eliminate it, fit 1kΩ trimpots connected as rheostats between the positive rail and the positive end of VR2 and VR3 and adjust them for a maximum count of exactly 1000 and 10,000 respectively.

To use the frequency meter, turn S3 on and S4-S7 off. Connect the signal to pin 11 of IC1 (PD6) of the micro. Now the LCD will display the frequency of the external source. As with the counter input, the peak voltage required is between 3V and 5V. The software uses both Timer0 and Timer1 for the frequency meter. Timer0 serves as a time reference while Timer1 is employed as a counter. The maximum frequency measured is 4MHz.

The software, *AVRTimerCounter.bas* and *AVRTimerCounter.hex* can be downloaded from the Silicon Chip website.

Mahmood Alimohammadi, Tehran, Iran. ($65)

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Whistle From Hifi Stereo Valve Preamp

I have built the Stereo Valve Preamp from the January 2016 issue and I have a high-frequency, low-level noise from both channels. I guess it is around 6-10kHz and while its a low level, it is audible.

I was wondering if there were any changes to the power supply since the January article or if this has been raised by other readers/builders. I have verified that all component values are as per the article so I am surprised there is the problem.

It would be nice to get rid of the tone as it performs well otherwise and it would be nice to use it in the longer term. (G. H., Dandenong, Vic.)

- The most likely reason why there would be whistle from both channels is that the MC34063 is running at the wrong frequency. It should run at about 100kHz, as set by the 150pF capacitor at pin 3. We tip that the capacitor you have installed is between 1.5nF (1500pF) and 2.5nF (2500pF).

We note from the photos you sent that you appear to have very little ventilation in your preamp's case. That might lead to overheating if you use it for long periods and would not be good for the 39µF 400V electrolytic capacitors.

Note: the diagnosis proved to be correct: the wrong capacitor had been installed – Editor.

run OK with the SCR or will it reduce the intensity of the pulse and/or cause more RFI? (J. E., Coondle West, WA).

- The BT137X 600E fuses at a much lower integrated current value (I^2t) than the originally specified BTA10-600 Triac. So the charge in the 7µF capacitor could well destroy the device.

An SCR can be used in this circuit as the voltage applied to it is only DC. The C122E has a similar I^2t rating to the BTA10-600 and so should be suitable. The output to the electric fence and the RFI shouldn't be any different than when using a Triac.

Fixing a garage door remote control

I have a B&D Controll-a-Door 4 and the receiver will no longer work and cannot be replaced with a new unit as they are no longer made. However, the manual switch still works correctly, raising and lowering the door.

I am thinking that if I had a receiver that would operate a relay, I could use this remotely. The relay could take the place of the switch and be operated by the remote from the car and a button in the garage.

I have three remote transmitters, all 433MHz. The remote switch in Silicon Chip, January 2009 looks interesting but would it operate using my transmitters? (N.G., Cohuna, Vic.)

- The remote switch from January 2009 could be used but you would need to use the transmitter designed for it, as described in the January 2009 issue. The B&D 433MHz transmitters would not work with this unit.

Note that the January 2009 remote switch does not have much security and it would be desirable to build a higher security rolling code system such as the one published in October and November 2007. This incorporates encoding that changes each time the transmitter is used, making it virtually impossible for anyone to open your garage door without the correct transmitter. Altronics (www.altronics.com.au) sell kits K1957 and K1958 for the transmitter and receiver respectively.

Converting a clock to drive a giant display

I would like to convert a standard 230V digital clock to have giant displays, either large 7-segment displays or made up from multiple single LEDs and housed in a larger case. This would be a simpler project than the recently published GPS clock with large displays, as it just involves changing the actual displays and keeping the rest of the clock.

What do you think? (B. P., via email).

- Converting your digital clock to large 7-segment displays could be a difficult task.

For example, are the existing displays vacuum fluorescent or LED 7-segment, common cathode or common anode and is the clock supply voltage high enough to drive the large displays? And will you need level translation between the clock chip and the display drivers?

When all those aspects are taken into account, building our large 6-digit clock, with or without GPS, is a much more straightforward task.

Ultra-LD power supply voltage

I have almost completed two of the Ultra-LD Mk.3 Amplifier kits from Altronics and wish to use an existing power supply (part of a Luxman 150 amplifier) which is rated to provide (and measured off-load) ±52V. These supplies have 15,000µF storage capacitors included.

Do you recommend that I make any changes to any circuit values in view of this slightly changed power supply voltage? I have no intention of running the modified amplifier at anywhere near full power, believe me; my speakers are very efficient, being a JBL system with folded horns etc.

The Luxman 150 amplifier will use the Ultra-LD amplifier modules in place of the original amplifier modules and the whole thing will be prettied up with an extended frame at the rear to accommodate the two new modules and heatsink.

By the way, my choice of kits was determined by the fact that there is no way I could use the recent surface mount version of the amplifier; at my age my soldering hand is not steady enough! Do keep up the good work in the magazine. (M. M., Latrobe, Tas.)

- ±52V is close enough to the specified supply voltage that no changes should be required. The power output will be slightly reduced, as will heat dissipation at idle and at low power levels.

Passive volume control for Ultra-LD amplifier

With reference to the Ultra-LD Mk.3 Amplifier (I know the Mk.4 is out but I'm too old and clumsy to handle SMD components!), I plan to build it purely as a power amplifier; ie, no preamp. I would therefore like to add a manual (non-motorised) volume control pot at the input. What is the best way to do this without compromising its performance? (N. H., Flinders, Vic.)

- Use a dual-gang log potentiometer of no more than 10kΩ. 5kΩ would be a better value (lower noise) and if you are using modern source equipment

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uch as a CD/DVD/Blu-ray player or IP3 player it should not have trouble riving such a load. In that case, 2kΩ vould be OK.

Basically, lower values are better ue to reduced thermal noise but you on't want to load down the signal ource equipment too much (the limit epends on what it is).

Good quality log pots are likely to have better tracking and low-end performance than cheap/no-name pots. We suggest Alps, Bourns or Panasonic brand potentiometers if you can get them, using either cermet or conductive plastic material. Bourns has a range of potentiometers designed for amplifiers – see **www.bourns.com/products/proaudio/products** Similarly, for Alps: **www.alps.com/prod/info/E/HTML/SearchList/Search-List1050_list1.html**

Three-way crossover advice

I am building a 3-way speaker system using Klipsch K33 15-inch bass drivers, JBL midrange horns and JBL Super Bullet tweeters. I want the crossover frequencies to be around 350-550Hz and 3.5-5.5kHz. How can I design a crossover to achieve this?

The midrange JBL driver has a 2-inch throat and is able to work down to 350Hz with the JBL 2886B horn. The

Notes & Errata

Ultra-LD Mk.2 Amplifier Module, August & September 2008: in the printed version of the magazine, on page 71, the panel "Bullet-Proofing The Ultra-LD Mk.2" reads "Fortunately, this was relatively simple and involved adding a 22kΩ collector current-limiting resistor to Q9 (ie, this resistor is connected between Q9's collector and ground)."

This statement is incorrect. The resistor is, in fact, added between Q8's collector and ground to limit the current through Q9, as shown in Fig.18 on page 70 of the same issue.

Note that the panel has been removed from the on-line version as the circuit diagram in the August 2008 issue on the website already incorporates the changes mentioned in the print edition.

Touch-Screen Boat Computer With GPS, April 2016: version 3 (V3) software is now available for this project, with the following improvements:
(1) Fixed a problem which may cause the BASIC program to repeatedly crash and restart if a point of interest (POI) is created with longitude and latitude set to 0° (the default).
(2) Now allows over 50 points of interest (POI) to be created. In the main selection screen, you now use the PREV and NEXT buttons to take you through the list of POIs.
(3) The heading indicator and POI direction indicator are now suppressed when the boat is stationary.
(4) Improved rendering for the heading needle.
(5) Removed the slash from the zero character in one of the fonts.

Ask SILICON CHIP

. . . continued from page 103

JBL Super Bullet Tweeters go down to around 3.5kHz (model 2402). The cabinets are still under construction.

I have a 60W/channel class-A Amcron Power Line 3 stereo amplifier to drive the woofers. I also have a Cary Sixpac 50W/channel amplifier to drive the mid-range loudspeakers. It uses six EL34 tubes and is a Class-A monoblock. I intend to get a 12W/channel tube amplifier to drive the tweeters.

Can you help? (F. J., via email.)

● Since you are using separate amplifiers for each driver, you will need to use an active 3-way crossover. We can't advise you on the exact design since we don't have the details of the enclosure, the efficiencies of the various drivers and the required crossover slopes (eg, 6dB/octave, 12dB/octave etc).

However, we did publish a 3-way active crossover design in the January 2003 issue which you may be able to adapt for your purposes. We can suggest our Currawong valve amplifier to drive the tweeters (October 2014 to March 2015): **www.siliconchip.com.au/Issue/2014/October/Currawong+Stereo+Valve+Amplifier%3A+A+Preview** SC

Next Issue

The July 2016 issue of is due on sale in newsagents by Thursday 23rd June. Expect postal delivery of subscription copies in Australia between June 23rd and July 7th.

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